CHAPTER 7.--MAINTENANCE

7.1 General

Preventive maintenance practices are listed in the manufacturers' instruction books. In general, equipment that requires frequent and extensive preventive maintenance is generally the most costly. The manpower spent on these frequent trips to remote areas is such that it is usually better to invest in a more costly system which requires little preventive maintenance. The best preventive maintenance for the system is a good installation.

7.2 Preventive Maintenance and Inspections

With any system, periodic inspection is required because of the corrosive atmosphere and adverse conditions that exist in underground mines. These inspections can spot potential trouble in the system. Repair or replacement at that time averts the possibility of losing effectiveness of all or part of the system.

7.2.1 Cables

Approximately once per month all cables in the communications system should be inspected for kinking, chafing, cracking, wear, stretching, or other signs of physical abuse. Particular attention should be paid to cable glands at the entry or exit points to the various units in the system, where the cable goes around sharp corners, in the vicinity of holding cleats which may be clamping the cable too tightly causing potential damage, and across the areas where the cable is exposed to physical damage from outside sources, such as equipment or falling objects. If a cable is damaged, it should be replaced as soon as possible.

It is mandatory that the ground leads and connections to carrier current phones be thoroughly inspected and maintained in good condition, since considerable hazard may exist to the operator or equipment if a ground connection is broken.

7.2.2 Pager Phones

The most readily available test set to determine if a pager telephone is operating correctly is the pager phone itself. The following physical check of the system can be performed at any phone station.

7.2.2a Listen Circuit

Remove the handset from its cradle and listen to determine if the circuit is functional, as indicated by the presence of noise or conversation on the line. If no noise or voice signals are present at the handset receiver, take the following corrective action:

1. Operate the handset press-to-talk switch several times. Any corrosion on the contacts of this switch may cause a receiver to be temporarily inoperative. Repeated operation may clear the condition.

2. Open the cabinet and see if the battery cables are properly connected and are making firm contact. Check the handset cable and its connections in the cabinet of the pager phone, and see if there is any evidence of a break in the cable, corroded contacts, or poor connections.

3. Remove the handset receiver earpiece by unscrewing it counterclockwise (to the left), and remove the receiver from the socket. Examine the handset cavity; in some units, a patch of cotton batting or floss is used as a barrier to reduce acoustic feedback in the handset. If the cotton patch has absorbed moisture, remove it and replace with a crumpled ball of soft rubber, stuffed just far enough into the handset so it will not touch the receiver or switch terminals.

7.2.2b Page Circuit and Talk Circuit

Push the page switch, squeeze the handset press-to-talk switch, and call any other phone. Release the page switch and listen for a reply. If the background noise is too high, or if the received signal is either too weak or too garbled to be understood, then repairs should be initiated to improve that particular telephone. The phone should be replaced by an operable unit and repaired by qualified personnel. Ask the answering party if the paging signal could be understood, and also check the quality of your received signal. Have the other party page you to verify that your speaker works. Some of the most common problems with the pager phone system that can be remedied by good installation and maintenance practices are: very low voice levels and very high noise levels.

Often, the sources of these problems are--

1. Poor placement of the phone line (near rectifiers, motors, etc.).

2. Using too light a gage phone line.

3. Using the wrong kind of wire for the phone line. The line should be of the twisted two-wire type. Nontwisted line of any gage is not acceptable. It is the *twist* that provides a great deal of noise immunity.

4. Poorly made splices. These cause high resistance and leaky joints in the line that lower the signal and increase the noise. (Note that the phone systems always are worst in the summer months. This is because the high humidity is affecting the splices.)

7.2.2c General Comments

If any of the signals is erratic, low in signal level, has exceptionally high noise levels, or is unintelligible, check whether other phones in the system are having similar problems. If not, replace the defective phone with a good one. If the other phones are not operating properly, it is possible that the problem is in the line. A cable may be short-circuited, improperly spliced, or running too close to noise-producing power or trolley lines. Such conditions should be corrected.

In the environment of underground mines, switch contacts are particularly susceptible to erratic operation because of corrosion or oxidation of the switching contacts. This is particularly true of contacts that are used infrequently. Repeated operation of each of the switches in the telephone may aid in clearing some of the corrosion and restoring the phone to more reliable operating condition. Cleaning individual contacts should not be attempted with a phone in service; it should only be done by trained or experienced repair personnel, who have approved burnishing tools specifically designed for use on switch contacts.

7.2.2d Battery Condition

The battery condition of a pager phone can be approximately checked by pushing the page button and calling some other phone to determine whether or not the paging signal is sufficiently strong to energize all relays within the system. Of particular importance is whether or not the battery has sufficient voltage to energize the paging relay of the telephone farthest from the phone being tested. Therefore, one of the most distant phones should be called. Batteries can also be checked with a voltmeter to judge if they are near the end of their life or in a marginal state. There are several methods of measuring the available battery voltage as noted in the following section.

7.2.2e Battery Testing

Most pager phones are powered by one or two 12-volt batteries of the NEDA 923 or 926 drycell type. These are 12-volt, metal-cased batteries that measure 2-3/4 inches wide, 5-1/4 inches long, and 4-3/8 inches high. The difference between the two types is that the 926 has two screw terminals for lead attachment and the 923 has a two-prong connector system for lead attachment. For those phones using a 24-volt system, two batteries are connected in a series. In consideration of intrinsic safety, it is common to find some means of current limiting, such as a 50- to 100-ohm resistor and a fuse in series with the battery system, to limit the maximum current flow. Batteries are approaching the end of their useful life in a system when the available voltage at the terminals has dropped 25% from the rated value measured under load conditions. In a 12-volt system, this is approximately 8 to 9 volts; in a 24-volt system, it is 16 to 18 volts.

Measurement of the battery voltage can be made by connecting a dc voltmeter across the battery terminals, pressing the page switch, and reading the battery voltage. Measurement of battery voltage on the line will not give a true measure of the battery condition, because of the added voltage drop in the current-limiting resistor.

Remember that it is useless to measure the output of a battery not under load. Under these conditions, even the poorest battery will still maintain its rated terminal voltage.

It is not always practical to carry a voltmeter into all sections of a mine, and checking a battery requires that the phone enclosure be opened. The following scheme can minimize such difficulties.

A voltmeter can be permanently installed at some convenient location aboveground, such as in a repair or maintenance shop.[1] The meter is connected across the line so that it continuously indicates any dc voltage on the line. A listing of voltage readings is made from each remote phone at this reference station, when the individual phones are paging with new batteries installed. A chart is then made of the allowable reduction in voltage for each phone by estimating a 20% to 25% reduction from the new battery condition. Reference to this chart can give advance warning of the approximate condition of each battery and will provide guidance for planned prelacement. A periodic check can be made of each phone by requesting a page from each of the phones and maintaining a log of the voltage readings. This will assist in maintaining an up-to-date status of the battery condition at individual phones. This procedure will remain valid as long as the phone system is configured as it was when the original listing was made. Substantial change in the phone system could require making a new chart.

[1]This could violate MSHA intrinsic safety standards; check with MSHA for application details.

7.2.3 Carrier Phones

CAUTION

Some of the procedures discussed in this manual are undertaken with the in-mine trolley wire energized and are therefore very hazardous. Extreme caution must be exercised to avoid accidental electrocution. Fuses used in test leads protect only the equipment and do not provide any protection from shock hazard for the operator. Do not attempt any of the electrical tests or installations described in this manual unless you are qualified for such work and are thoroughly familiar with electrical work on trolley wires.

Each of the carrier phone units should be examined for any external physical damage. All fixing screws must be tight. All connectors and externally accessible fuses should be checked for proper seating.

7.2.3a Microphone

The carrier phone microphone is a delicate piece of equipment and is most prone to abuse by handling or dropping. The microphone should be examined for evidence of physical abuse. The action of the transmit relay can be observed by pressing the transmit button and listening for the transmit relay inside the transmitter (in units where such a relay is used) to produce a sharp click. The microphone quality can then be assessed by transmitting a test count to a remote unit; the operator of the remote unit will judge the quality of the voice he receives and report back to the unit being tested so that the receiving quality of the unit being tested may also be assessed.

7.2.3b Batteries

Two different types of battery systems are used in carrier phones. One is a conventional car battery type or wet lead-acid cell, and the other is a gelled electrolyte battery. Both types should be tested once a month to insure a proper state of charge, and the electrolyte should be checked in wet lead-acid batteries, if possible. The gelled electrolyte battery is also of a lead-acid construction; however, its so-called dry electrolyte system cannot be changed since the cell is sealed to prevent any electrolyte loss. Overcharging of either of the battery types causes considerable electrolyte loss, and both types of battery can be ruined if overcharged for a long period of time.

CAUTION

Electrolyte loss also happens to a lesser extent during a normal charge cycle and results in the emission of hydrogen and oxygen from the cells in a ratio which is explosive. Slow emission of this hydrogen and oxygen gas mixture in the enclosures using a gelled electrolytic battery can create a hazardous mixture of gases inside the units. Some units are vented to prevent a pressure buildup inside the enclosure, but this is insufficient ventilation to prevent the possible buildup of a hazardous atmosphere inside the box. Thus, transceivers using a gelled electrolyte battery should only be opened in a well-ventilated area where there are no possible sources of ignition of the hydrogen and oxygen mixture before it is sufficiently diluted by the surrounding air to become harmless. Wet lead-acid batteries should be placed in a well-ventilated area in the vehicle to prevent buildup of pockets of dangerous hydrogen-oxygen mixture.

7.2.3c Wet Cell Maintenance

If a car-type wet cell lead-acid battery is used, it should be installed in a well ventilated area easily accessible for routine maintenance. Each week the level of the electrolyte in each cell should be checked and restored to its proper level by the addition of distilled water. The electrolyte should read a specific gravity of approximately 1.275 on a battery-testing hydrometer when the battery is fully charged. The voltage for each cell should be between 2.2 and 2.4 volts. Since in normal operation the battery is under continuous charge, the specific gravity and voltage of a battery in good condition should be around the stated values. Values significantly less are symptoms of problems with either the battery or the battery charger and should be investigated. If electrolyte is lost from the battery due to spillage, then electrolyte premixed to the same specific gravity should be used to refill the battery to its normal level.

Terminal posts on lead-acid batteries should be examined and cleaned each month. Petroleum jelly may be used to coat these posts to prevent corrosion. Also, any corrosion of the battery box should be scraped clean, and petroleum jelly should be applied to prevent any further corrosion.

If a vehicle equipped with a carrier phone is to be taken out of service for some time, then both battery leads should be disconnected to prevent discharge of the battery while the unit remains in standby mode. Again, petroleum jelly should be applied to the battery posts and the terminals to prevent any corrosion.

Any battery found to be in a weak condition should be removed for recharging and replaced by a fully charged battery. If a particular vehicle has repeated battery problems, the battery charger in that vehicle should be removed for checkout.

7.2.3d Gelled Electrolyte Battery

It is not possible to service the electrolyte in a gelled electrolyte battery since it is sealed at the factory. However, these batteries do vent small amounts of hydrogen and oxygen during the charging process, which will increase to larger amounts if the battery is overcharged. Normally, the battery should be charged by a taper-charge process. This means that when the battery is in a discharged condition, the battery charger can apply a comparatively large amount of current to build the charge up in the battery quickly. However, as the battery charge increases, the charging rate should decrease. When the battery is almost fully charged, the charging current should fall to zero or maintain a very small charge. Each of the two types of carrier phones using batteries of this type have a taper-charge-type battery charger built in to maintain the cells at a fully charged state, without the hazard of overcharging.

The important parameter to measure for proper gelled electrolyte battery maintenance is the battery voltage. A nominal 12-volt gelled electrolyte battery is fully charged when it reads 13.8 volts across the terminals. This should be the voltage reading when the battery has been fully charged by the operation of its battery charger. Any voltage higher than 13.8 is an indication that the battery is being overcharged, thereby suffering a considerable loss of life due to the drying out of the electrolyte. This also causes generation of dangerous quantities of hydrogen and oxygen gas mixtures as the cell vents. If this is the case, the battery charger should be examined for malfunction.

Alternatively, if the carrier phone has been left on for an extended time without any battery charging from the trolley wire, it is possible for the battery to become moderately or deeply discharged. A moderately discharged battery can be removed for recharging and generally will not suffer any significant harm. However, if the battery is deeply discharged and stored in this condition without being recharged, the battery may develop a condition where it cannot be recharged and should be replaced.

7.2.3e Troubleshooting on the Vehicle

When an operator reports a malfunction carrier phone, initial diagnosis of a problem can be carried out using only the equipment suggested in table 7-1. The repairman may either take his equipment to the faulty vehicle, or the faulty vehicle may be returned to the test and maintenance area.

First, the battery voltage should be checked to make sure it has not become discharged. If it is found to be good, all external fuses in the unit should be checked. If a faulty fuse is found, it should only be replaced with a fuse of the proper rating. If the fuse blows again, then the unit is probably faulty. It is possible that replacing the blown fuse with a new one will cause the unit to operate properly since a momentary overload could have caused the original fuse to blow.

Sometimes the phone itself can provide valuable information on the nature of a problem. Use of the carrier phone will generally isolate the problem into one of the following three categories.

1. Cannot transmit to others or receive from others:

    a. Check the main fuse.

    b. Check the ground connection.

    c. Check all connectors for corroded contacts.

    d. Check all cables for breaks.

    e. Check the battery condition.

    f. If cause cannot be readily located, replace with spare unit and take the malfunctioning unit in for bench maintenance.

TABLE 7-1. - Suggested test equipment

Item	Type	Use
Multimeter.......	Various............	Meter can be used for measuring voltages in and around the unit, power consumption, power output, and fuse checking. In order to give useful results for transmitter power output measurements, the meter should be capable of operating with frequencies of at least 100 kHz.
Fuses............	...do..............	Fuses provide an intentionally weakened part of an electric circuit, and thereby act as a safety valve in the event of dangerous overloads. This protects both personnel and equipment from potential fire hazards due to overheating of the carrier phone. A blown fuse generally indicates that some part of the circuit of the carrier phone has become defective. Occasionally a temporary external overload condition can cause a fuse to blow; hence it is a useful practice to change a blown fuse one time to see if the unit can be brought back into service. Should the fuse blow again, then a more detailed trouble-shooting process should be attempted.
Substitute units.	Same as used in the mine.	Each carrier phone consists of a number of different units interconnected by cables. To facilitate troubleshooting on the vehicle, a fully operational spare set of the type used in the mine should be maintained so that initial trouble-shooting can be performed by substitution of the individual units.
Hydrometer.......	Battery type.......	The hydrometer measures the charge-discharge condition of the battery electrolyte.
Distilled water..		A battery with a low level of electrolyte will require an addition of distilled water.
Petroleum jelly..	Any................	Coating the battery terminals with petroleum jelly aids in preventing corrosion.
Battery charger..	Any applicable (for wet battery) or special battery charger for gelled electrolyte battery.	The battery charger is used to recharge batteries that have become discharged. NOTE.--Insure equipment is suitable for desired application.

2. Can hear others but cannot apparently transmit:

a. Check cables and connectors (especially the microphone for corroded contacts or breaks).

b. Replace the microphone.

c. If neither the above is at fault, the problem is probably in the transmitter; take the malfunctioning unit in for bench maintenance.

3. Cannot hear others but they can hear your transmission:

a. Check the volume control setting.

b. Check the cables and connectors for breaks and corrosion.

c. Replace the speaker assembly by substitution.

d. Check the squelch setting.

e. If none of these measures solve the problem, it is probably in the receiver; replace the transceiver with a spare unit and take the malfunctioning unit in for bench maintenance.

If all these steps fail to make the unit operational, then repair by substitution is usually the quickest way of getting the unit into operation again. Substitution should be in the order of items considered to be more or less vulnerable. Unless it is obvious which unit is faulty, the process should be carried out in the following order:

1. Change the microphone assembly and test for normal operation.

2. Change the transceiver assembly and check for normal operation.

3. Change the loudspeaker unit and check for normal operation.

4. Where relevant, change the battery charger box and check for normal operation.

When the faulty unit has been isolated and replaced, it should be returned to the repair area for a more detailed examination, including an overall performance checkout after the fault has been isolated and repaired.

CAUTION

The following procedure is undertaken with the trolley wire energized; therefore, it is extremely hazardous. Extreme caution must be exercised to avoid potentially lethal shock. Only personnel thoroughly familiar with electrical work on trolley wires should conduct the test procedures. Equipment used must be appropriate for this application.

On 300-volt systems, a test can be made of the transmitter power output onto the trolley line. A simple method of measurement in the field makes use of the multimeter with the range selector switch set to the 50-volt-ac scale. The black meter lead should be plugged into the column (-) terminal of the meter and the free end connected to the ground. The red lead must be plugged into the meter output jack and connected to the trolley wire. The trolley pole must be in contact with the wire. A reading of 15-volts or more when the transmitter is keyed indicates normal operation provided the test is made at least 200 feet from the nearest power rectifier that supplies the trolley wire. This test cannot be performed on 600-volt dc systems since this voltage will overstress some components inside the multimeter. In this case, the unit should be returned to the repair shop for a standard bench test. It should be noted that the meter will respond to ripple present on the trolley wire; thus a base reading of up to 10 volts will be shown even with the transmitter off.

7.2.3f Mapping Signal Levels

The maintenance of trolley carrier phone systems requires not only the maintenance of the equipment involved, but the maintenance of the transmission line (trolley wire-rail) used to transmit the signals (refer to paragraph 5.3.1). Evidence accumulated over the years indicates that this signal path is subject to many loads that impede the propagation of carrier signals.

One of the most useful ways of determining the state of the overall transmission system is to map the signal and noise strengths at various points throughout the mine. Such mapping requires a tuned signal-measuring device.

The mapping is preferably carried out by measuring the signal produced by the dispatcher's transmitter at various points along the rail haulage system where vehicles operate. A satisfactory way of conducting the measurements is to place a suitable tuned voltmeter aboard a mine vehicle (such as a jeep), and at appropriate places along the rail haulage--for example, at 2,000- or 3,000-foot intervals--measure the received dispatcher's signal and background noise. These values should be noted on a mine map for future reference as the mine expands, or as carrier phone problems occur. Except under extremely unusual conditions, the signal-strength map produced in this manner will also indicate the level of signal that a vehicle transmitter at the measuring position would produce at the dispatcher's place. A portion of a mine map with signal and noise readings is shown in figure 7-1.

The equipment for making such a signal-strength map must be battery operated, easily portable, and easy to use and read. Two such units commercially available are shown in figure 7-2. These tuned voltmeters are general-purpose, battery-operated instruments appropriate

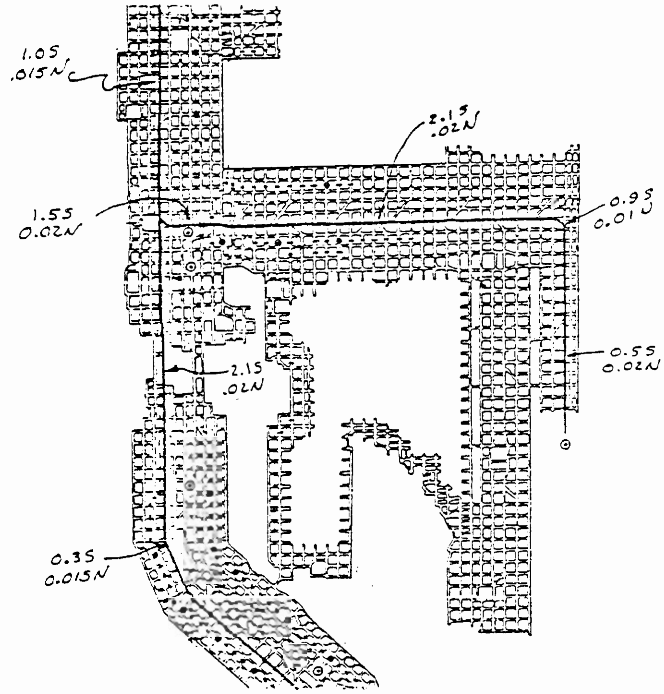

FIGURE 7-1. - Example of signal level map.

for many tasks other than the mapping of trolley carrier signal levels. For this reason careful attention must be paid to the tuning of the instrument to the precise frequency, attenuator settings, and meter indications. Table 7-2 gives specifications for these tuned voltmeters.

The simple straightforward procedure of measuring the dispatcher's signal level from a jeep or vehicle moving about the mine can best be accomplished by connecting the trolley wire voltage on board the vehicle to the input of the tuned voltmeter. Because of the hazards associated with the high voltage of the trolley wire, either voltmeter has to be properly isolated so that personnel operating the instrument are not subjected to this voltage through error in operation. Therefore, it is important that a capacitor and a fuse be connected in the series with the instrument to insure that the potentially lethal voltage of the trolley wire does not inadvertently reach an operator. Figure 7-3 shows a possible way of connecting the instruments.

TABLE 7-2. - Key specifications of tuned voltmeters

Specification	Sierra 127C	Rycom 3115
Frequency range.................kHz..	2-350	3-200
Accuracy:		
Frequency....................kHz..	±1	±1
Level.........................dB..	±1	±1
Selectivity (standard 250 Hz), Hz:		
3-dB bandwidth....................	250	1,000
35-dB bandwidth...................	600	NAp
60-dB bandwidth...................	1,000	4,000
Ranges (full scale).................	1 mV to 10 V	-37 to +13 dB (3.7 mV to 1.65 V)
Intermediate frequencies, kHz:		
1st...............................	1,305	NAp
2nd...............................	330	NAp
Power requirements..................	6 zinc-carbon or 7 NiCd rechargeable D-size cells	2 gel cells Globe 610
Voltage.............................	9 (nominal)	12
Battery life (zinc carbon)....hours..	100	5 (continuous)
Temperature range...............°C..	-10-50	-10-55
Dimensions, inches:		
Width.............................	12	7-1/4
Height............................	7-1/2	5-1/4
Depth.............................	7-1/2	7-3/4
Weight......................pounds..	15	6

NAp Not applicable.

WARNING

Disconnect the instrument when the vehicle is moving. Transients from the vehicle motor can cause damage.

CAUTION

The following procedure is undertaken with the trolley wire energized; therefore, it is extremely hazardous. Extreme caution must be exercised to avoid potentially lethal shock. The fuses used in the test leads serve only to protect equipment and do not in any way reduce the shock hazard to personnel. Only personnel thoroughly familiar with electrical work on trolley wires should conduct the test procedures. Equipment used must be appropriate for this application.

To make a measurement, the vehicle is moved to the desired location in the mine and stopped. The operator then asks the dispatcher to "key" his transmitter for a 5-second transmission of unmodulated carrier. The response on the indicating meter is noted, together with any attenuator setting, so that an absolute value of voltage (in volts rms) can be noted on the corresponding position on the mine map. It may be necessary when starting measurements to switch the range knobs of the instruments to make sure that the instrument's response is on scale rather than high and off the scale. In this event, perhaps two transmissions will be required before on-scale readings are obtained. After the transmission from the dispatcher is recorded, the sensitivity of the instrument should be increased and the noise level at the particular position noted again in volts or millivolts rms.

The signal-level map will reveal regions of the mine where the dispatcher signals are weak which may cause difficulties in carrier communication. The mine map will also reveal regions where

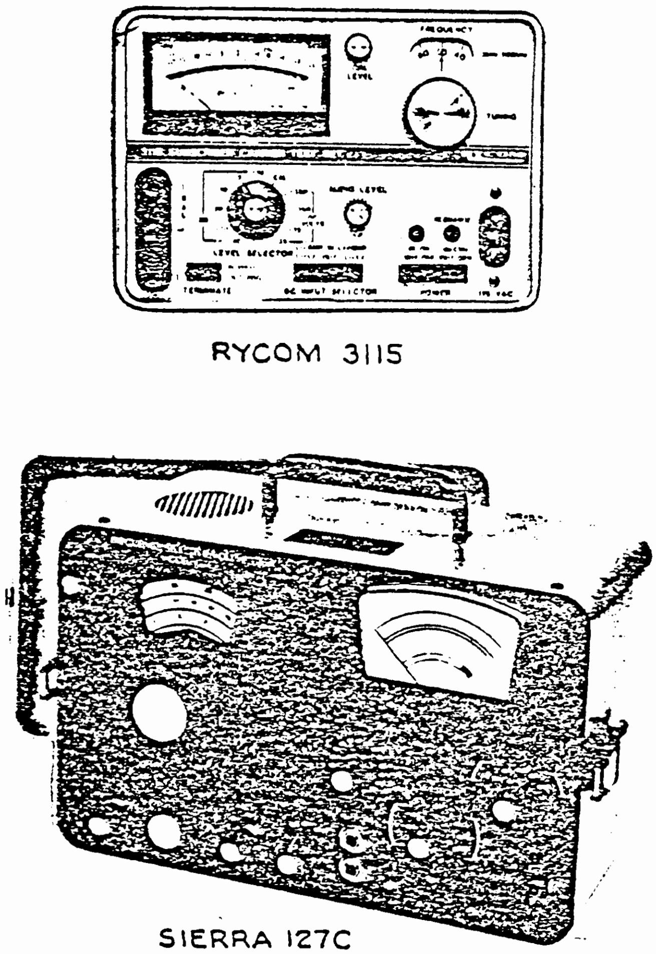

FIGURE 7-2. - Tuned voltmeters.

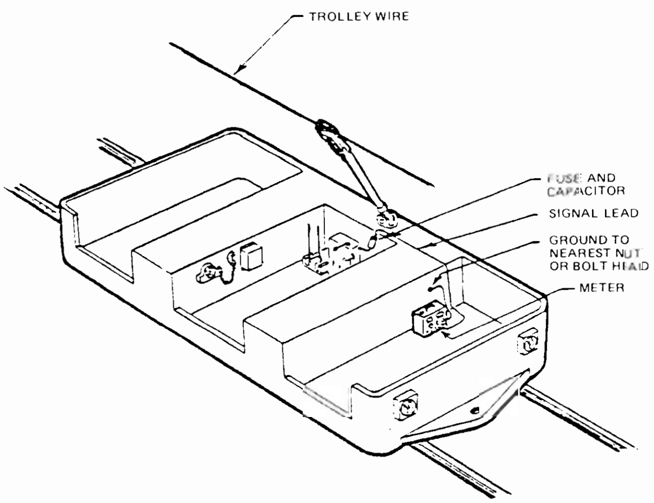

FIGURE 7-3. - Instrument connections.

excessive noise is the main cause of poor communications. In this event, it is important to locate the source of the offending noise and to take measures to alleviate the problem.

The signal-level map will also be extremely useful should carrier communications deteriorate with time, with the installation of new equipment, or with the advancement of the mine. Reference can be made back to the original signal levels to determine if and why communications have been degraded.

7.3 Summary

Good preventive maintenance and periodic inspection practices are the key to successfully maintaining any communication system. Common problems that can affect communications include:

Corrosion or conductive dust on battery terminals.

Cable abrasion and line breaks.

Corrosion on switch contacts or in cable splices.

Weak batteries.

Blown fuses.

Weak or broken springs on spring-loaded connectors.

Poor splicing techniques.

In addition to problems that develop owing to normal system usage and environmental conditions, trolley carrier systems may be affected by characteristics of the trolley wire and rail itself. Poor signal strength may result because of bringing loads across the trolley wire-rail or high signal attenuation rates in the trolley wire. Methods of compensating for the effect of bridging across the wire-rail are given in section 5.3.1.

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APPENDIX A.--COMMUNICATION SYSTEM EXAMPLES[1]

A.1 INTRODUCTION

Because no two mines are identical, there is no "one best system" that can be defined to meet the requirements of all mines. The following examples of system installations are presented to indicate how some mines have adapted available equipment to meet their particular requirements. Selection of examples were based on the goal of obtaining the widest possible range and cross section of the following characteristics:

Type of mine

Age and size of mine

Electrical power usage

Haulage methods

Existing communications

Usefulness of present communications

Examples A through F are of coal mines utilizing various combinations of magneto, pager, and conventional trolley-carrier-type phone systems. Example G is of a magnetite ore block-caving operation where a radiating cable and radio system is used. Example H indicates how a dial-page phone system can be utilized in a coal mine. Example I presents a multi-channel (multiplexed carrier) system presently in use in a deep metal mine.

A.2 MINE A

Mine Description

Mine A is part of a connected four-mine complex. This particular mine is approximately 20 years old, and although there are some new working sections, the major coal extraction is from retreat mining where pillars are being pulled. Personnel entry is achieved through a vertical shaft approximately 545 feet deep. Coal is removed from the face area by shuttle cars and placed in a set of six tracked haulage cars. When full, the sets of cars are combined into trains and brought to the surface through a slope entry. Average coal production is 4,000 to 5,000 tons per day for 240 working days, setting yearly production at approximately 1 million tons.

The mine size is currently 2.4 miles north and south by 3.9 miles east and west with overburden from 545 feet to 1,000 feet. All tunnels and haulageways are typically 6.5 feet high by 14 to 15 feet wide. An average working section is 425 feet by 300 feet long, and 10-foot roof bolts are used. The mine has only one borehole, which is used to supply the mine with water.

Currently the mine has six working sections of which five are worked every shift. The shifts run from 8 a.m. to 4 p.m., 4 p.m. to 12 p.m., and 12 p.m. to 8. a.m. A typical working section cycle starts with the continuous miner cutting coal and filling a shuttle car. When the shuttle car is full, the driver moves the coal load to the tracks and transfers the coal to one of the six haulage cars positioned on the side track. The shuttle car then returns to the continuous miner to repeat the cycle. Excluding mechanical trouble, the continuous miner will cut a block of coal 5 feet high, 15 feet wide, and 16 feet long in 1 hour, and a section can mine five blocks this size in an 8-hour shift. The mine typically has 100 men underground per shift.

Mine Equipment and Power

The prime power for the mine is 550 volts brought in on a feeder cable. In the mine the trolley wire is run parallel to the feeder cable. At the working section the continuous miner, shuttle cars, and car pull are run off the 550-volt-dc trolley line fed at nip stations. Compressed air is used to run the roof-bolting machine.

[1]Use of company names is for identification purposes only and does not imply endorsement by the Bureau of Mines.

The equipment at each working section includes one continuous miner, two shuttle cars, one roof-bolting machine, and one car pull. Other equipment includes 3 bottom-loading machines, 2 minor-type cutting machines, and 12 pumps.

The tracked vehicles include 3 dual locomotives or tandems, 24 Jeeps, and 3 portal buses.

Present Mine Communications

The present communication consists of a carrier phone system and a magnetophone system. All vehicles are equipped with FEMCO carrier phones, and all active working sections, along with selected underground positions, have Western Electric magnetophones.

Telephone System

The heart of this mine's communication system is a central dispatcher located at the bottom of the main shaft.

Eight party-line magnetophone circuits terminate at a simple switchboard in the dispatcher's office. Each of these 8 circuits has several of the 41 telephones wired in parallel. Calls between circuits must be made through the dispatcher and his or her switchboard, whereas calls within a circuit need not. The dispatcher can connect any two phone circuits together and can make two of these connections, generating two independent phone circuits for two-channel operation.

Since this magnetophone system operates with a bell ringer rather than a loudspeaker, the rings are coded to indicate certain places or individuals. The dispatcher communicates through a single headset, and selection of either the mine phone or the carrier phone is made using a two-position switch. Other switches connect and disconnect the various mine telephone circuits.

This dispatcher controls all vehicle traffic and serves as a telephone operator. Operator duties include answering phone calls, switching phone circuits, personnel calling and location, and taking and relaying messages.

Because the dispatcher is more likely to contact a working section through the motor and an associated carrier phone in that section, the mine phone is used relatively little compared with the carrier phone.

Based on the observed traffic density and on the number of phones in the system, the probability of a busy signal on the magnetophone system is 5%.

Trolley Carrier Phone System

Vehicle-mounted carrier phone usage during a typical shift is shown in figure A-1.

During a first shift survey, there were 182 dispatching calls, 20 calls relating to personnel location, and 58 calls relating to placing empty and loaded cars.

Communications Requirements--Users' Viewpoint

Evidence of this mine's interest in communications is shown by the expression of one foreman that "their production would be cut in half if they lost either telephone or carrier phone communications." An important communications. requirement as defined by the management of this mine concerned safety. They strongly felt that a secure channel was needed where only the persons calling and called could hear the conversation. There are two reasons for this: First, anyone seeking aid for an injured miner tends to belittle the seriousness of the injury because he knows that friends and relatives of the injured miner, and those just curious, will be listening to the conversation. The problem is not unique to this mine. Secondly, the phones of these eavesdroppers load the line to the extent that the emergency communications are impaired.

Based on this realistic situation, a basic communications requirement is a

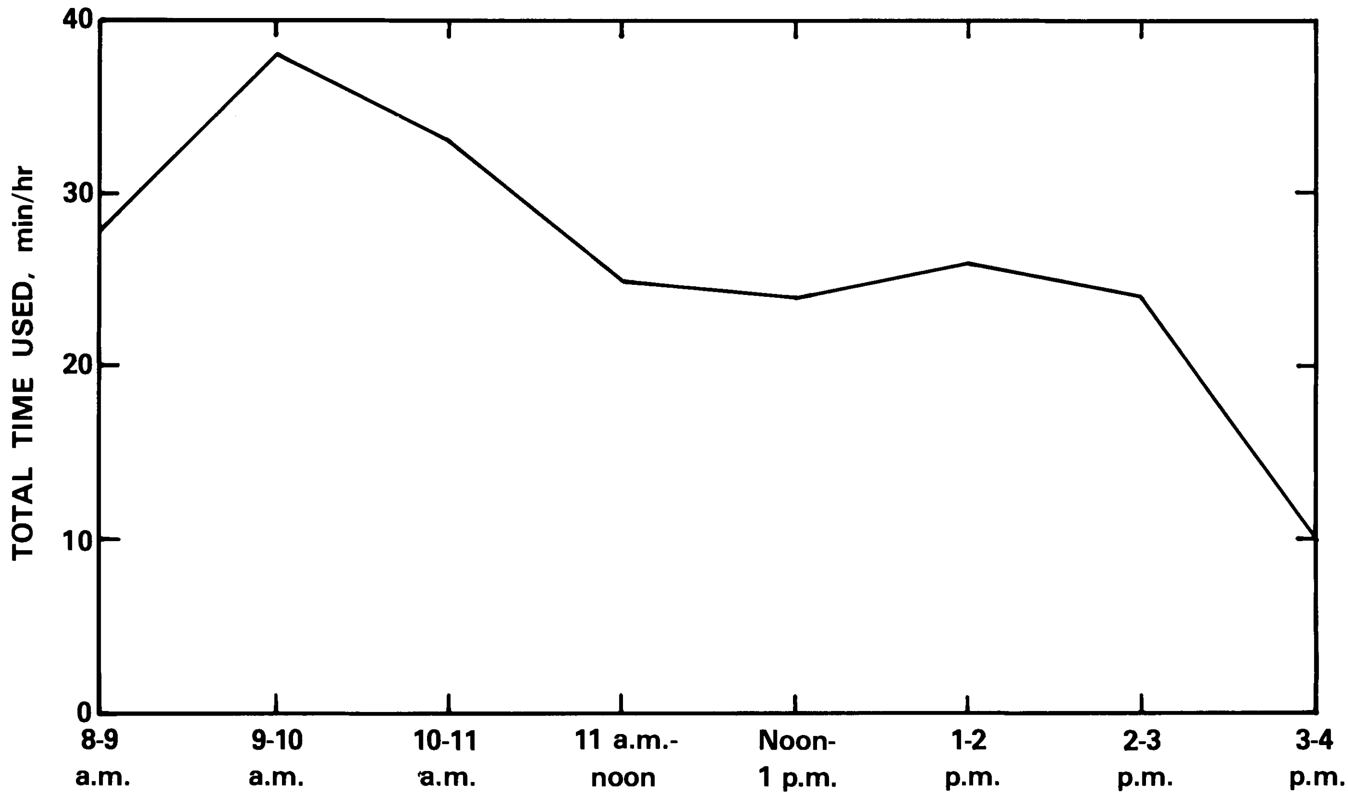

FIGURE A-1. - Vehicle-mounted carrier phone use in typical shift.

private line, selective calling channel over which the person attending an injured person can privately call, at his or her discretion, the mine foreman, the dispatcher, the safety foreman, or the nearest hospital or ambulance service. Note that a conventional private dial system meets this requirement. Mine C (described in section A-4) has a dial phone adjacent to each pager phone. This met the need for a secure channel for both management and emergency communications.

Communications Requirements--Based on Survey Analysis

Although the personnel interviewed felt the quality of their communications was adequate, analysis indicates that excessive noise and distortion were present. Therefore, a requirement that applies to this mine as well as to all communication systems is that of reasonable signal-to-noise ratio for good intelligibility.

The fact that the chance of getting a busy signal is 5% is proof that additional channel capacity is needed. Adding additional channels to a wired system appears to be an acceptable solution since these extra channels will minimize the telephone duties the dispatcher now performs and will eliminate the communication system blocking problem. Calculations indicate that a minimum of five communication channels are needed for this mine. Furthermore, making one of the five channels a private line will fulfill the requirement for private communications.

Also, from observing the mine operation and talking to various personnel it appears that section foremen, like the foremen in most industrial operations, are overworked, and yet are the key to improving productivity. Therefore, wireless communication is needed for at least the section foremen along with various other supervisors and maintenance personnel.

From this brief analysis of the mine and its current communications, the following is a list of minimum communication requirements for Mine A.

a. Reasonable communication channel signal-to-noise level.

b. At least five independent voice channels.

c. At least one secure voice channel, which may be included in the five voice channels.

d. Some form of wireless communication to select individuals on the working section or roving in haulageways.

A.3 MINE B

Mine Description

Mine B consists of adjacent (No. 1 and No. 2) low-coal mines. The No. 1 Mine employs longwall and continuous mining. The No. 2 Mine employs conventional and continuous mining and is preparing for its first longwall operation. Both mines employ belt coal haulage to closely located drift entrances. Men and supplies enter the No. 1 Mine by a 400-foot shaft remotely located from the No. 2 Mine drift entrance. From the two mines, 8,000 tons of coal per day are mined by about 600 union men under the supervision of about 60 officials.

The No. 1 and No. 2 Mines each currently employ one longwall mining unit and conventional working sections of Lee Norse continuous miners. For the No. 1 Mine's longwall mining, coal is moved by an armored face conveyor to a stage loader at one end of the longwall, to an extendable belt, and finally to a conventional belt.

In addition to longwall mining, the No. 2 Mine employs a full-dimension unit, a conventional mining unit, and continuous miners for seven working sections per shift.

The equipment used in conventional mining consists of a cutting machine, a loader, and two shuttle cars. With a full-dimension system, the shuttle cars are replaced by an extendable belt.

Coal is brought out of the two mines by conveyor belt, and men and supplies are moved by track. The coal is moved by belt from the two mines to a screening house having 1,250 tons of storage capacity. To cope with slacks and overflows, coal can be automatically diverted to a 12,000-ton-capacity storage pile.

Ac power is brought into the mines at 12,470 volts. Two rectifiers are positioned at every 6,000 feet of track, each with a capability of 300 kW, to supply 300-volt-dc power to the trolley wires and their feeders. In addition to supplying locomotives with power, the trolley lines supply power, at nip points along the line, for the operation of the 300-volt-dc shuttle cars. Where needed, the 12,470 volts ac is transformed to 600 volts to provide ac power for rock dusters, conveyor belt drives, miners, roof bolters, and belt feeders.

Present Mine Communications

The equipment used in each of the two mines includes paging-type party line telephones, trolley carrier phones, the fire sensor tape recording that would automatically be patched into the phone system should there be a belt fire, and the fan sensors that utilize the phone lines.

The No. 1 Mine's communications systems are independent of the No. 2 Mine's, but generally of the same size and equipment types. The No. 2 Mine's chief electrician's office has a No. 1 Mine phone, as does the No. 2 Mine's foreman's office.

Telephone System

Since both mines have similar communication equipment, only the No. 2 Mine will be described. The No. 2 Mine has 31 underground loudspeaking telephones. The underground phones are all in a single network. The following seven surface phones are also in this network:

Outside mechanics shanty--1

Outside shop--1

Auditorium--1

Chief electrician--1

Cleaning plant--2

Double breaker switchhouse--1

The paging phones used in these mines use 6 volts for normal phone use and 22.5 volts during paging. With these phones, pressing the paging button at any station permits the operator to broadcast through the loudspeakers on the remaining 37 telephones. On releasing the paging button the operator can converse with anyone who picks up the handset on any other phone.

Tape recordings were taken of both the No. 1 and the No. 2 Mine's party line pager phone system and the No. 1 Mine's carrier phone system. Analysis of these recordings revealed that for the No. 2 Mine, based on hour intervals, the most the system is used is about 50% of the time, between 9 and 10 a.m. But, based on 15-minute intervals, the phones are used nearly 90% of the time around 3:30 in the afternoon.

This heavy usage occurs during the last hour of the shift when section foremen are making their end-of-shift reports on production status, supplies on hand, supply requests, and maintenance work requests. The fact that the phone system is used 90% of the time signifies that other calls that could improve production efficiency must either be delayed or not made at all.

Carrier Phone System

A second means of voice communications is the carrier phone system that uses the dc trolley wire as a carrier of 88-kHz (No. 2 Mine) and 100-kHz (No. 1 Mine) FM. In each mine five carrier phones are used: One as a base station at the inside mechanics shanty, two on utility jeeps, and two on motors.

One shortcoming of the present carrier system is that there is no way for personnel with carrier phones to communicate with working sections. Mine personnel would like some way of patching the carrier and pager phone systems together.

Longwall Communications

Five permissible loudspeaking telephones are spaced at 125-foot intervals along the 500-foot longwall system. These five phones are connected together to form an independent communications system. Near the phones at either end of the longwall system are phones of the overall telephone network. Though not interconnected, the two phone networks are physically close to each other.

The five phones are identical to those of the main telephone system except that the paging mode is permanently wired into all five phones as a safety measure. Anything said into any one of the five handsets will be broadcast over all five loudspeakers, thus alerting all nearby personnel of activity on the longwall section.

Belt Maintenance Communications

Along the belt lines (every 2,000 feet) and at the belt heads are located phones of the telephone communications system. The belt heads are the only spots where belt mechanism fires are likely to occur.

Belt Fire Alarm System

Although these mines have never had a belt fire, their fire alarm system is better than required by law. A tape player is positioned underground and when activated will broadcast a warning over all telephone and carrier phone loudspeakers. The recorded message warns all personnel of the alarm condition, specifies the location of the tripped alarms, and advises personnel of safety precautions to be taken.

Fan-Stop Alarm

In the event a fan stops, provision is made for utilizing the phone systems to insure that proper action is taken. At the No. 1 Mine, where there is a phone at the fan site and where personnel are within earshot of an audible alarm, the person responding to the alarm can use the normal telephone system in seeking help. The fans for the No. 2 Mine are remote from any mine personnel so the alarm is automatically sent over a commercial phone line to No. 2 Mine's lamphouse.

Communications Requirements--User's Viewpoint

Through interviews and discussions with those who use, plan, and maintain the communications systems, communications requirements were determined that would aid production at these mines. These requirements dealt directly with mine operations not using a dispatcher, with operations where coal haulage is by belt only, and with operations involving low-coal and longwall mining.

The first suggestion made by mine personnel was that they needed someone to perform the communications and information center tasks often performed by the dispatcher in other mines. Presently they have no way of relaying messages between, or interlinking, the independent telephone and carrier phone systems. They also would like someone to monitor belt line sensors, from a center, in order to coordinate troubleshooting, maintenance, and repair of all belt lines. Thus, a requirement for a communications center operator (communications coordinator) would resolve the two immediate problems as well as many others.

Low coal and longwall mining combine in determining a requirement for fixed communications terminals to be close to all classes of foremen, and a requirement for personal hands-off-operation radios of insignificant weight and bulk. Coordinating the operation and and repair of a 500-foot longwall miner is difficult, especially in low coal.

Mine personnel felt that having nothing would be better than having a simple radio pager where a section foreman might have to crawl 700 feet to the nearest phone to find out that it really wasn't that important. If the section foremen are given anything for mobile communications, it must be small, light, and two-way. In this mine they would like the section foremen to be able to easily contact a general assistant foreman for supplies and repairs. The need for small portable two-way communications is shown by the case where someone at the mine, on his own initiative, tried some two-way units he had borrowed from a local hospital.

Communication Requirements--Based on Survey Analysis

An analysis of both the No. 1 and the No. 2 Mine survey indicates that the communications systems noise levels were unacceptably high and that communications capability is on the verge of becoming unacceptable. Improved communication and improved mining operation would result merely by improving the signal-to-noise ratio of the present communications systems.

Since the current phone traffic makes the chance of getting a busy signal between 350 and 450 times greater than most industries find acceptable, additional channel capacity is needed to reduce the chance of blocking to the 1% level. Although blocking is still 10 times greater than industrial standards, it appears to be a reasonable selection for mine communications.

Also, from observing the mine operation and talking to various personnel, it appears that section foremen and select longwall personnel need some form of two-way wireless communication of minimum size and weight. All personnel expressed a negative attitude toward any one-way type of communication.

Furthermore, the mine personnel felt they needed a location where the daily production activity could be monitored. This location can evolve into a communication center, since as the mine expands and more vehicles are equipped with trolley carrier phones, a combination dispatcher, call monitor, and production monitor can be financially justified.

Specifically for these mines, the following represents a minimum for future communication requirements:

a. Reasonable communication channel signal-to-noise ratio.

b. At least five independent voice channels to replace the present one channel.

c. Small, lightweight wireless two-way communicator units for foremen and select personnel.

d. A communication center.

A.4 Mine C

Mine Description

Mine C has been operational since 1903 with production originally estimated for 100 years. Coal is being mined in the B and C seams, and there is 36 to 60 feet of vertical displacement between these seams. The mine employs continuous mining techniques, and personnel enter the mine through a slope entry. Coal production is approximately 1 million tons per year and is removed by a combination of belt and haulage cars. The B seam has two active working sections, and each section transfers coal from shuttle cars to a small feeder belt. A longer mother belt then takes the coal to a main loader head. This loader head has the capacity for 18 cars; when 12 cars are filled, these cars are assembled into a 12-car train 240 feet in length for main line haulage. The C seam has only 1 working section, and coal is transferred by shuttle cars to a set of 6 haulage cars; 2 of these combinations of 6 cars are attached to make a 12-car train, which removes the coal from the mine.

The B seam is currently 1.7 miles north and south by 3.2 miles east and west; the C seam is 0.35 mile north and south by 0.45 mile east and west. The overburden ranges from 0 at the slope entry to 2,000 feet. All tunnels are typically 18 feet wide. The average C seam tunnel is 9 feet high, and the typical B seam height is 15 feet. Since the B seam has coal 22 feet thick in some places, the top level is mined first; they return to mine the bottom coal for maximum yield. Roof bolt length is typically 6 feet with variations from 4 to 12 feet. These bolts are positioned on 5-foot centers in the B seam and on 4-foot centers in the C seam.

The mine has one borehole into the B seam, which was used at one time for a phone line and another time for pumping water out of the mine. A second borehole in the C seam is used to pump methane out of the mine.

Currently the mine has two coal-producing sections in the B seam and one coalproducing section in the C seam. Furthermore, the B seam has one large cleanup section and two smaller cleanup or rehabilitation sections. A typical working section is 320 feet square. The mine has two production shifts and one maintenance shift, and they run from 8 a.m. to 4 p.m., 4 p.m. to 12 p.m., and 12 p.m. to 8 a.m. The mine has 71 men underground for the first production shift, 55 men underground for the second production shift, and 45 men underground for the last or maintenance shift.

Mine personnel typically require 20 minutes to get from the portal to their working sections, and they take 30 minutes for lunch some time between 11 a.m. and 1 p.m. These lunch periods are staggered between working sections. On the B seam the work cycle starts with the continuous miner cutting coal and filling a shuttle car. When the shuttle car is full, the driver transfers the coal load to one of the 36-inch 550-fpm belts run to the section. The belts then remove the coal to the south loader head, where it is loaded into cars that will make up the main line haulage train. The shuttle car round trip takes approximately 7 minutes to complete a work cycle on the B seam. Except for the shuttle cars dumping directly into haulage cars, the C seam has the same type of work cycle. Furthermore, the C seam has no belt haulage and uses tracked haulage for coal removal.

Mine Equipment and Power

Three surface substations convert 44,000 volts three-phase to 4,160 volts three-phase, the 4,160 volts is carried underground to various 440-volt-ac and 275- to 300-volt-dc power stations.

At the working sections, the shuttle cars are powered either by 440 volts ac or 275 to 300 volts dc; the continuous miner is powered by 440 volts ac, and the roof bolting machines are powered by 275 to 300 volts dc. The dc voltage can be obtained by either a trolley nip point or an ac-dc load center.

All trolleys are powered by a 275- to 300-volt-dc trolley line, which is a common ring bus fed by 300-kW rectifiers and two 500-kW rectifiers. The quantity and type of trolleys or vehicles follow:

Man-trip cars--7

Mechanics' jeeps--2

27-ton motor--6

13-ton motor--2

Present Mine Communications

This mine utilizes a combination of loudspeaking paging phones, dial telephones, and 88-kHz vehicle-mounted carrier phones. The carrier phone system is tied electrically to the loudspeaking paging phones by a trolley coupler. This type application should not be used with intrinsically safe phones. To improve communication coverage, auxiliary speakers are sometimes used with the loudspeaking paging phones. The following tabulation shows the number of phones and their general location:

Phone type	B seam	C seam	Surface	Storage	Vehicle
Dial telephone...	12	1	16	0	0
Loudspeaking pager phone.	5	1	1	1	0
Carrier phone	1	0	1	0	17

In general, vehicle operators and supervisory personnel use the trolley carrier phones, and mine section foremen, maintenance personnel, and supervisory personnel use the dial telephones and pager phones.

Dial Telephone System

The mine has purchased from the telephone company dial telephones, telephone environmental enclosures, associated PABX, and 25-pair telephone cable with wire size No. 19. All underground telephone equipment and wire was installed by mine personnel and has been in service for the last 10 years. Standard dial telephones are mounted in environmental enclosures.

The biggest problem the mine has had with the dial telephones was dust and moisture getting into the dial mechanism. This was understandable since it was found that the majority of the underground telephone enclosures had been left wide open and were liberally rock dusted. Of the eight underground telephones checked, seven were in good working order and one had rock dust in its dial mechanism contacts. Another problem, not related directly to the telephone equipment, was that of acoustic noise from mine machinery. For example, a telephone is required near the 3d south loader head, and mine personnel find communication difficult when the loader head is in operation. Mine officials have considered building a telephone enclosure that will shield this telephone from external acoustic noise.

Other than leaving the door to the environmental enclosures open, the mine personnel appeared to operate the telephone system properly. The telephone was mostly used to call from underground stations to surface stations or call out of the mine. Most calls were for supplies, maintenance, and location of personnel. This telephone system was also used as a backup system when communications were bad. For example, once personnel were contacted using the trolley carrier phone or pager phone and extended conversation was needed, the person would be instructed to go to the nearest dial extension telephone and reestablish contact to complete the communication.

Over the history of the mine, only one major emergency has occurred, a destructive fire. This fire destroyed the telephone cable, and the underground dial telephone system could not be used for emergency personnel evacuation. This points out the basic weakness that telephone systems without loopback paths have during a real disaster situation.

Loudspeaking Paging Phone--Carrier Phone System

Carrier phones installed at the mine include six 10-year-old units and thirteen 14-month-old units, all with 88-kHz center frequency. The mine personnel plan to replace the older carrier models with new models in the near future. The carrier phone to paging phone coupler (<u>an application that cannot be used with an intrinsically safe phone system</u>) is of standard manufacture, and auxiliary speakers are used with the paging phones where the need arises. The loudspeaking paging phones communicate through a pair of wires from the 25-pair telephone cable, and the carrier phones use the dc trolley wires for their signal paths.

With the exception of service problems with the older carrier phones, all carrier and paging phones are of good quality, are holding up well, and are apparently being properly used by working personnel. However, there is a problem associated with the carrier phones communicating from certain dead zones in the mine to the surface. Another problem with the carrier phones was that the battery had to be serviced every 30 days and mine personnel said this was excessive. Also, the mine officials indicated that the ringfed trolley rectifiers added receiver noise and that additional rectifier line filtering helped but did not eliminate the local problem when the trolley was near the rectifier stations.

External audio noise and replacing the internal battery approximately every 90 days were the most annoying problems associated with the loudspeaking paging phones.

Although the two systems are electrically tied together, the loudspeaking paging phone was primarily used to reach the working section and the carrier phone was used for right of way, placing loads and empties, personnel location, and requesting supplies. When the trolley-mounted carrier phone was used for self-traffic control, the operator would twice give his location and destination and then proceed to his final destination. Although this method of traffic control worked for this mine, an improvement could be seen using a dispatcher.

Tape recordings for a first 8-hour work shift survey show that the most frequent call made was concerned with right of way. Also, it was noted that out of the total 296 calls on the trolley and pager system, only 8 were on the pager. By listening to tape recordings of both the pager and the carrier phone simultaneously, it was discovered that 78 calls out of the 296 were not heard on the outside trolley carrier phone. It was also found that the trolley-to-pager hookup failed on 12 occasions. The actual failure of the coupler to function on some signals and the propagation dead zones were major problems associated with this system.

During the fire previously mentioned, the carrier phones were the only communication that worked through the evacuation. The telephone wire was fused, and communication was not possible using the dial system. However, the carrier phones could and did operate, using their internal batteries, through the fire. Although the loudspeaking phones were not in widespread service at the time of the fire, their line would have also been fused, making them inoperative if and when needed.

Communications Requirements--User's Viewpoint

Mine personnel indicated that the most urgent communication requirement was the elimination of dead zones in their trolley carrier phone system.

Communication between the shuttle cars and from the shuttle cars to the continuous miner was also thought to be useful. However, there was apparently no great need or requirement for this type of communication.

Portable two-way wireless communication for the maintenance foreman, fire boss, miners on the weekend inspection, and working section foreman was noted as a possible requirement. If portable two-way wireless equipment costs were high, the maintenance foreman, roving supervisors, and key personnel could use a one-way pager. However, mine personnel did not consider equipping a working section with a one-way pager since a working section foreman mostly communicates out from his location and is seldom called from other sections or surface locations.

A requirement existed for battery-operated portable emergency communications that could be moved with the miners as the working section moved. This requirement became evident during the fire, when it would have been useful during the emergency and recovery efforts. Also noted was the fact that if the number of working sections increased, the mine may economically justify a dispatcher.

Communication Requirements--Based on Survey Analysis

This mine is unique in that it has a dial telephone system, a pager system, and a carrier phone system. The mine, as configured, has no need for additional channels, private channels, or the capability to interconnect to the public phone since the dial telephone has all these capabilities.

From the traffic density seen on the pager phone and trolley carrier phone system, only two additional channels can be justified to get the probability of blocking to the 1% level. However, only 3% of this communications is from the pager phone system, and the vehicle communication system must be single-channel operation for safety reasons. Therefore, there exists no justification for additional channels for the pager phone. Using this analysis and the needs generated by the mine personnel, the following list was developed to represent communication requirements for this mine.

a. Reliable two-way vehicle communication.

b. A dispatcher with communication center if the mine increases appreciably in size.

c. Portable two-way wireless communication for working section foreman, maintenance foreman, and key personnel.

d. Portable battery-operated communication equipment for mine-to-surface emergency two-way communication.

A.5 Mine D

Mine Description

Mine D was opened in 1892. Even though the mine is old, they are still developing in some areas. At present they have eight sections on development and five on retreat. It is estimated that there are 15 years of mining left.

The mine is entered through one of two drift mouths. A vertical shaft is available but is seldom used. The mine produces approximately 4,500 tons of coal a day by the conventional, continuous, and longwall mining methods in the following percentages:

First shift:	
Conventional	18
Continuous	35
Longwall	10
Other shifts	37
Total	100

The coal is removed from the mine by track to the cleaning plant about 2 miles from the mine. The mine has an annual production of about 1,300,000 tons.

The mine is 7 miles by 5 miles and has overburden from 300 feet to 800 feet. All haulage tunnels are at least 6 feet high by 18 feet. There is no average size for a working section; some are as much as 3,000 feet in length. This requires that coal be removed from the working face to the track by belt. The belt is 36 inches in width, and the mine has approximately 25,000 feet of belt. If the distance is short (less than 500 feet), it is possible to dump coal from the shuttle car directly into the coal car.

Eight 37-ton locomotives are used to remove the coal. The mine has 30 miles of track underground at present. Eight boreholes are used to provide access for 13,800-volt-ac, three-phase, cables to the mine. Roof control is obtained by the use of roof bolts ranging in length from 42 inches to 8 or 9 feet.

Owing to the amount of track and layout of the mine, it is necessary to have two dispatchers. This mine is also engaged in strip mining at various locations directly above the mine. This coal is taken to the same cleaning plant as is the coal mined underground. This requires that dispatcher 1 dispatch right-of-way outside as well as underground.

The mine employs a total of 675 men and works three 8-hour shifts each day, with the major production done on the first shift. The start and end of each shift and the total men working follow:

First shift:	6:45 a.m. to 3 p.m.--308 men
Second shift:	3:30 p.m. to 11:45 p.m.--216 men
Third shift:	12:15 a.m. to 8:30 a.m.--151 men

Mine Equipment and Power

Power is provided by the power company at 138,000 volts ac. This is then stepped down to 13,800 volts ac and distributed to eight boreholes, where it is taken underground. At some point underground it is converted to 250 volts dc, 550 volts dc, or 440 volts ac three-phase, depending on the equipment being used on the section and location in the mine. One of the reasons for this is that from the outside to dispatcher 2, the mine uses 550 volts dc on the trolley. Then branching out from dispatcher 2, the mine uses 250 volts dc on the trolley. The 440 volts ac is used in both areas.

The power provided to sections varies according to the type of equipment used. There are cases where, on the same section, 250 volts dc or 550 volts dc must be provided for the shuttle cars, and 440 volts ac provided for the miner. Both longwalls require 440 volts ac, as do some of the newer continuous miners. There are also battery-powered scoops on some sections. They are used for cleaning the section and hauling supplies.

The mine at present uses the following equipment:

Continuous miners--8

Loading machines--5

Longwalls (1 plow, 1 shear)--2

Cutting machines--3

Shuttle cars--29

Present Mine Communications

At present, the mine communication system consists of a magnetophone system, carrier phone system, and loudspeaking phones.

The loudspeaking phones are used only on the longwalls. Carrier phones are placed on most of the track vehicles. At the cleaning plant a 60-watt amplifier is used as a public address system calling 14 stations, each of which has a microphone and speaker.

Each dispatcher is responsible for carrier phone and magnetophone control in his area of the mine. The two dispatchers must consult with each other when routing traffic toward each other. Typically, the telephone network having dispatcher 2 as its control point has heavier traffic of a more varied nature than that of dispatcher 1.

During the busiest period of the shift, the fourth hour, the busier trunk was used 70% of the time. This three-channel traffic intensity implies that there is a 30% chance of getting a busy signal on any given call. This is considerably worse than the one chance in a thousand of commercial telephone standards. A six-channel network would be required to bring the system to commercial standards.

There have been no major emergencies at the mine to test the existing system. It is possible that a roof fall could break the phone line and cut off communications to the outside for some areas of the mine. In the case of an accident the section notifies the dispatcher, who in turn calls mine management on the outside.

Telephone System

The mine has 77 magneto telephones, 60 of which are underground. These phones are approximately 30 years old. They use simple twisted-pair, No. 14 wire for the phone circuit.

The phones are usually mounted on wood that is connected, in some manner, to the roof. They are placed at locations along the main haulage. Phones on the section are located at the head and tailpiece of the belt. These phones are not permissible.

The dispatchers are the heart of the phone system. Dispatcher 1 is responsible for the outside phones and for underground phones 1 to 20. Dispatcher 2 has phones 20 to 60. If a person wished to call outside from say phone 57, he would have to ring dispatcher 2. Dispatcher 2 would then call dispatcher 1, who would ring outside, then connect the lines.

Since the phones are a ringer type, each station must have a certain ring. It should be kept in mind that the circuits for the two dispatchers are separated. Therefore, each dispatcher could use the same ring combinations.

Recordings and corresponding analysis of the traffic on the phone system shows that there are periods when the system is used 70% of the time and that the system is overloaded at times.

Trolley Carrier Phone System

The carrier phones are mounted on most of the track vehicles. The fact that the mine uses 250 volts dc and 550 volts dc on the trolley requires the use of two different carrier phones. They have twelve 250-volt, 163-kHz trolley phones and twenty-eight 550-volt, 100-kHz phones. Both tube and transistorized versions are used. The tube type is 20 years old, and the transistorized type is 12 years old. The transistorized units are equipped with a 12-volt battery, so that they will still operate should the power in the mine go off.

Pager Phones

Pager phones are used on the longwalls and on the outside of the mine. The pager phones are mounted on J-hooks from the roof support jacks. Wires are hung from the roof supports for the phones. Rocks falling between the jacks have caused the line to break, causing a potential safety hazard due to interrupted communication. The reason for this is there is no way of hearing a ring on the pager system. There are 10 pagers on the plow and 5 on the shear. The phones are 10 years old. The mine personnel felt that the phones were mistreated by man and environment, and that was the reason for failures.

Fan Monitors

The size of the mines requires that the fans be located at great distances from the maintenance shop. The fans are monitored by sending a signal over the high-voltage lines, which is monitored at the outside shop. The five frequencies used (one for each fan) are 39, 116, 47, 61, and 33 kHz.

Communication Requirements--User's Viewpoint

The phone system performed very well considering its age. However, the changes in humidity caused some problems. There was also a problem with having to walk long distances. The phones are not permissible; this limits how close to the working face they can be placed and often requires that an individual walk as much as 500 feet to reach one.

Mine personnel felt that wireless communications of some type would be of help on a section. The foreman and the mechanic are the two most sought after individuals on the section. The mine personnel were of the opinion that communications to those two men would be desirable.

The maintenance foreman and master mechanic felt that portable two-way communications would decrease the time needed to locate them. Portable communications are also desired for the supervisory personnel (superintendent, mine foremen, and maintenance foremen). At the same time a private line was requested for the phone system for supervisory personnel.

The safety department personnel suggested that remote monitoring of the mine conditions would help increase safety for the entire mine. It was suggested that a private channel directly to the outside for emergency use would decrease the time required to get help from the outside. This private channel would also insure that the occurrence of an accident would not be heard by men on other sections.

There should be a secure channel open at all times, from any phone underground, to some central communications center aboveground. It is not necessary that this line be connected to the commercial phone system. Since the mine management are the first to be notified in case of an emergency, they in turn can call whomever is needed. In a mine this size the time saved by placing the call from underground to the commercial system for assistance, then notifying management, would be of little help.

Communications Requirements--Based on Survey Analysis

This mine has some communication problems that are related only to the extreme age of the equipment used. However, problems due to the large size of the mine may be typical of other large mines.

Signal-to-noise ratio (SNR) causes problems when talking great distances (5 to 10 miles). A new system must start by improving SNR on long-distance converations, which may be typical of many large mines.

An analysis of the telephone traffic density indicates that three more channels (total six channels) would make the system comparable to an estimated mine standard of 1 in a 100 chances of getting a busy signal.

A dial system is recommended for this mine. A multipair or multiplex system would help to lessen the load of the dispatcher and could also provide the capability for conference calls. These systems also provide the channel privacy requested by mine management. For safety reasons, the trolley carrier phone system should remain one channel.

Using the above analysis and the suggestions of mine management, the following list of improvements was derived:

a. Reliable two-way vehicle system.

b. A total of at least six channels to meet minimum standards.

c. At least one secure channel.

d. Portable two-way wireless communications for certain key personnel.

e. Battery-operated communications equipment that will work during an emergency.

f. A communications center located at dispatcher.

A.6 Mine E

Mine Description

Mine E has a drift entry in a 5.5-foot soft coal seam. The working sections are presently 3.5 miles in from the entrance, with the possibility of eventually working at twice this distance. Mining at the present rate gives the mine a life of from 30 to 40 years. The mine operates two longwalls about 500 feet wide and will travel a range of 3,500 feet. New to mining in this area is the "stall machine" used at the tail end of the plow longwall to give better roof control. This machine is a limited travel shear that leaves a cleaner end on the longwall than the plow. About one-third of the mining is by longwall, one-third is conventional, and the last third is continuous. The number of working sections for each type of mining follows:

	1st shift	2d shift
Conventional.......	2	2
Continuous.........	2	2
Longwall...........	1	1

Only a small amount of mining is done during the maintenance or third shift. The mine is small enough that there is no underground maintenance shop. Hence, repairs that cannot be made at the site of the failure must be made outside.

Coal is moved from the face by shuttle car except on the longwalls, where it goes directly to belt. Local belt haulage is used between the shuttle cars and tracked cars on the main line. The longest belt run is 4,500 feet.

During the first shift there are no idle sections so there is no need for maintenance crews when each section crew has its own mechanic. Extra mechanics work along the main line during this shift and help section mechanics when needed.

During the third shift, when few sections are working, there are three maintenance crews whose specific job is to work on equipment at the idle sections.

Mine Equipment and Power

Power is fed to the mainline trolley wire at 250 volts dc by four rectifiers. There are deadblocks between the four sections of trolley wire so that each rectifier supplies power to only one short length of wire. All face-mining equipment is ac operated so there is no need to have nip points from the trolley line.

Rather than utilizing power boreholes, 7,200-volt ac power is brought in along the mainline, up to transformers at the working sections. There the voltage is stepped down to 440 volts. Thus as the sections advance, the transformers must be moved to follow.

The only power outages have been due to storms or hunters shooting transformers on the power company's distribution system. Outside there are two high lines feeding the mine's single substation.

Should there be a power interruption within the mine, the substation attendant will check by telephone with the sections before reenergizing the distribution system.

Present Mine Communications

Telephone System

Pager phones are used in a network of 11 phones along the track throughout the mine, plus a phone in the dispatcher's outside office and one at the communication repair station in the shop. Tape recordings made during an 8-hour shift indicate that there were 160 discussions concerning the location and movement of empty and loaded coal cars. For the next most common topic, there were nearly 80 discussions concerned with the production of mined coal. Collectively the other subjects (reporting, personnel location, maintenance, etc.) add up to about 80, so no one of them is a significant user of channel capacity. Analysis showed that early in the shift, and just before the end, the phones are used as much as 50% of the time. This places the probability of a potential caller finding a busy line at one chance in two during these periods.

The loudspeaker telephones have an average age of about 4 years. Rock dust does seep in through their cases, but the users and maintenance men report there are few failures and these fall in no consistent pattern. The people interviewed could give no suggestions on how the phone system--the one following the track--could be improved. There are several reasons that could be contributing to their satisfaction:

a. The phones are relatively new.

b. The phone network is not large.

c. The time and talent spent on maintaining the system are great.

d. The equipment supplier gave them much help in setting up their systems.

e. The characteristics of the phone lines are good.

The telephone network is such that anyone on a working section is never more than 350 feet from a phone. They feel this is adequate and that having a phone any closer would not really be of more value. Other phone locations are the boom and tailpiece of every belt, plus four in the escapeway. No allowance has been made for emergency usage in the sense that, should a telephone line be broken, there is no loopback to carry the signal.

Carrier Phone System

The carrier phone is a 72-kHz system that uses the trolley power line to carry the signals. Even though this is a fairly small mine, they did experience dead zones of unacceptably low signal strength in certain areas.

The dispatcher has an outside dial phone as well as a speaker phone, so he serves as a message relay center and information center as well as a dispatcher. The communications maintenance area of the shop also has a trolley carrier phone to aid the maintenance people in servicing the trolley carrier phone system. The carrier phones do not have storage battery backup. If there is a failure of trolley power, carrier phone communications are lost.

The mine has had a dispatcher for only the last 2 years. Before that, motor operators controlled the track for themselves. At that time the mine tried tying the telephone system in with the trolley phone system (this type application cannot be used with an intrinsically safe telephone system) but found it only added confusion to have those not near the main line hear all the discussions of the motormen.

To get the carrier signal around the deadblocks, 2-μF capacitors are used.

To keep rectifier "hash" out of the 72-kHz system, L-filters are used at each rectifier (paragraph 5.3.1a). The filter consists of a 50-μF capacitor across a rectifier's output, with a 10-turn, heavy-cable coil, the coil having an approximate diameter of 2 feet. The manufacturer tuned the filter to reject 72-kHz interference.

CAUTION

Installation of equipment in a mine should be done only by people thoroughly qualified to do such work. Installations should follow procedures recommended by the equipment manufacturer and should comply with good safety practices. All installations should also comply with applicable codes and regulations.

Longwall Communication System

The longwall miner has its own communications system consisting of seven loudspeaking telephones, one at each end and the other five equally spaced along the 500-foot longwall. These loudspeaking telephones have no handset and thus operate in the pager mode only, with the loudspeaker serving as a microphone when the push-to-talk button is pressed. The telephone lines lie in the troughs that carry the hydraulic lines. At one time the wires were hung under the top plate of the jacks, but slate falling between the jacks kept breaking the wires.

Signal lights are positioned along the longwall miner so the operators can coordinate their efforts if the phone system fails. The quality of speech reproduction for the phones was good, and the loudspeaker volume was adequate in spite of the high ambient noise of the miner.

The only complaint the personnel had was that the push-to-talk button failed often. This button is mounted on the recessed front face of the unit. The phones at the ends of the longwall are mounted horizontally so the recessed panel acts as a catch basin for the watered-down coal dust. Evidently the directional properties of the speaker are such that this mounting is necessary.

Communications Requirements--User's View

Except for correction of the minor problems already presented, the mine personnel had little to suggest about new communications systems that would make their work safer and more effective. This may be due to their present system being new and seemingly adequate for this size mine, or due to their not having time to visualize how a higher capability system might profitably be utilized.

The one desire expressed at this mine was for a secure channel for seeking aid for an accident victim. As in other mines, when an accident is being reported, everyone who knows the phone is being used for this purpose will listen if he can. This lowers the productivity of the eavesdropper; takes his mind off his work, making him more accident prone; and worse, loads the telephone system so that the dispatcher can no longer clearly understand the report. It is not essential that the conversation cannot be listened to, just that personnel not become aware that someone in a panic is calling the dispatcher. Personnel seldom listen in on run-of-the-mill conversations.

Communications Requirements--Based on Survey Analysis

The exceptional high quality and the unusual amount of care given to the telephone and carrier phone systems leave little to suggest as to improving these communications means in mines similar to this one.

This mine, like some others visited, has a need for a secure channel as an aid in effectively handling injury problems, and it would be desirable to have a secure management channel.

Better communications capability would increase productivity in the longwall mining sections. Fast, effective hands-free communication is needed by operating personnel during both operation and repair of the miner. Because of its high production rate--and thus the high cost of downtime--and because of the almost impossible working conditions, it seems essential that all longwall workers have their own wireless communications network with each having small, lightweight equipment, including speakers and bone-conducting microphones mounted in helmets. The communication center operator should also be able to monitor this network.

A.7 Mine F

Mine Description

Mine F has been operational since 1963 with production originally estimated for 25 years. Coal is being mined from the Mammoth Seam in the Cherokee Group. Seam thickness is approximately 60 inches.

This mine is the only nonunion mine surveyed. As a result, some of the operations are notably different from those seen at the other mines examined.

The mine employs conventional mining techniques and employs tracked haulage to remove the coal. Personnel entry and coal removal are through a single shaft.

Coal production is approximately 250,000 tons per year. There is one mining section, operating one shift. Coal is mined via the room and pillar method with activity rotating through six active rooms.

The mine will ultimately be approximately 1-1/4 miles square. Mining activity is currently occurring about 3/4 mile from the shaft.

The overburden at the shaft is 157 feet, increasing gradually to the working face. Tunnels are typically 12 feet wide and range from 4 to 6 feet high. Four- and 6-foot roof bolts are installed on 5-foot centers.

There are no boreholes into the mine. The fresh air entrance serves as the emergency exit and is located about 500 feet from the main shaft. The main shaft serves as the air exhaust.

Mine Management

Since there is only one mining section, the mine operates with very few management personnel, as follows: General manager, chief engineer, superintendent, and foreman.

Management personnel do quite a bit of filling in as necessary; however, the chief engineer normally tends to topside operations while the superintendent stands by at the bottom of the shaft. The foreman remains at the face. The mine has 25 men underground during the shift.

There are five mining operations rotating continuously through the six active rooms at the face. A cycle starts with the cutter undercutting the coal face. This is followed by the coal driller drilling holes for the charges. After the driller moves on, the charges are set and fired by the shot firer. After a delay for the air to clear, the loader is moved in to begin loading shuttle cars, which transfer coal to the haulage cars. When a room has been cleaned of the loose coal, the roof bolters move in to extend the supported section of the roof.

Loaded haulage trains are pulled to the shaft where the cars are dumped into a skip, one car to a skipload. The skip is lifted up the shaft and dumped into the crusher. Crushed coal is conveyed into semitrailer trucks that are used exclusively to haul the mine's output.

The maintenance philosophy of this mine results in a large amount of nonproductive machine time. There is a complete operating spare for each type of machine in the mine. As a result of this philosophy, however, there is virtually no downtime for equipment maintenance. A minor failure is repaired on the spot; in case of a major failure, the spare machine is placed in service while the broken one is fixed.

There is no fixed shop location. The maintenance personnel travel with the mining crew. The presence of spare machinery permits repairs and maintenance to be performed thoroughly without slowing production.

Supplies are delivered via the haulage cars. Just before the end of each working day the foreman calls his list of supplies to the hoisting engineer. These are placed at the top of the shaft and delivered to the face either at the end of the day or the beginning of the next one. Repair parts are delivered during the day via a return trip of the haulage cars.

The mine has a single man-trip car. This is sufficient to carry the entire crew, so only one man-trip is made, morning and evening. Administration of the mine operation is quite informal. The general manager oversees all operations and assists the topside personnel as necessary. All management personnel assist when and where needed.

Ventilation is via a single fan, blowing into the escape shaft and exhausting through the main shaft. Within the mine, water sprays are used to keep dust down. There has never been any problem with excessive water, so the only water-handling gear is that used to control dust.

Mine Equipment and Power

The following pieces of mining equipment are in use at the mine:

Shuttle cars--3	Roof bolter--1
Loader--1	Coal drill--1
Cutter--1	Locomotives--3

In addition to the equipment in use, there is one operating spare of each type of machine. In case of major breakdown the spare is placed in operation while the broken unit is repaired.

Primary power comes into the mine through the main shaft. A 2,300-volt, three-phase line is run to the two transformer-rectifier sets used. One transformer feeds the trolley for the haulage system; the other powers all machinery at the face. All machines in the mine run off 280 to 300 volts dc.

Present Mine Communications

The mine currently has a combination of three independent voice communication systems. The loudspeaking phone system uses two units, one located at the hoisting engineer's position, and the other at the working face. A two-station intercom connects the top and bottom of the shaft. Another intercom connects the hoisting engineer and the mine office. Two spare loudspeaking pagers serve as backup and permit a third station to be patched in if work is being done a long way from the face. The hoisting engineer serves as "communications central," tying the three systems together. In addition to the internal communication systems, an extension of the outside telephone line is located at the chief engineer's desk. The pager at the face is kept mounted near the power sled, so the two are moved together. Nothing else is moved.

All equipment has been holding up well. Perhaps twice a year, one of the pagers will quit operating. Whenever this happens, the bad unit is removed and sent to a commercial repair station.

In normal system use, all calls are made from a remote point to the hoisting engineer "communication central." As long as calls are being made in this manner, the system functions well. A possible exception might occur in an emergency situation at the face. The pager at this point is 50 to 100 feet from the nearest working room, and on the other side of air-diverter flaps. It is conceivable that an accident could occur in which the phone would not be accessible. The other possibility involving an accident situation would involve the phone cable. There is a single run with no backup or loopback path. This cable is, however, protected in being mounted on vertical timbers and is of armored construction.

When calls are made from the "communication central" position to other parts of the mine, the system does not work so well. A complaint was made that if the superintendent leaves the bottom of the hoist it may take a half hour to get a message to him. It appears very unlikely that a call to the pager at the face would find anyone near enough to hear it. The fastest route to the face appears to involve relaying a message to a motorman at the hoist and having him deliver it to the face when he returns.

In this mine, communications efficiency would be improved by replacing the three independent two-station phone systems with a single multistation, multichannel system. The system should have a minimum of seven stations.

Their locations would be as follows:

Mine office

Hoisting engineer's position

Shaft bottom

Working face

Bottom of emergency shaft

Midway between bottom and face along inbound haulageway

Midway between bottom and face along outbound haulageway.

Other stations that might be considered include--

Topside storage or shop area

Chief engineer's desk

Crusher

Most of the added stations would be concerned more with safety than with production. As things stand, it is possible to be blocked from a phone station or to be a long walk from one. In addition to the fixed stations, the management personnel should have radio communicators. This would eliminate the existing situation in which a critical man can be out of touch when others need a decision or information.

An expanded system needs no more than two general channels plus a private channel. Radio communicators operate best if they can access all three channels, but could operate with access only to one of the general channels.

The cable into the mine should be a continuous loop of armored wire for maximum reliability and protection. By using a multiplex system, all channels plus monitors could be included on a single cable.[1]

A.8 Mine G

Mines that do not employ rail haulage systems powered from a trolley wire face unique problems in establishing satisfactory communications between haulageway vehicles. Because common trolley carrier phones cannot be utilized, some other form of radio system must be used to establish the required voice link between motormen and/or motormen and a central dispatcher. This description illustrates how one mine in this category solved its haulageway communication requirements using a unique system of UHF and VHF repeaters combined with a "leaky coaxial" transmission line.

This mine was a magnetite ore block caving operation. Surface access to the Mine (fig. A-2) was by two vertical shafts to the No. 6 production level, 2,500 feet, with mining occurring at a depth of 2,500 to 2,800 feet. Diesel-powered, rubber-tired loading equipment was used to transport ore to the crushers. A conveyor belt ran between the crusher rooms and the ore skip storage bins where the ore was automatically loaded into 20-ton skip cars and hoisted to the surface.

[1]Approved and nonapproved systems may not share the same cable; check with MSHA for details.

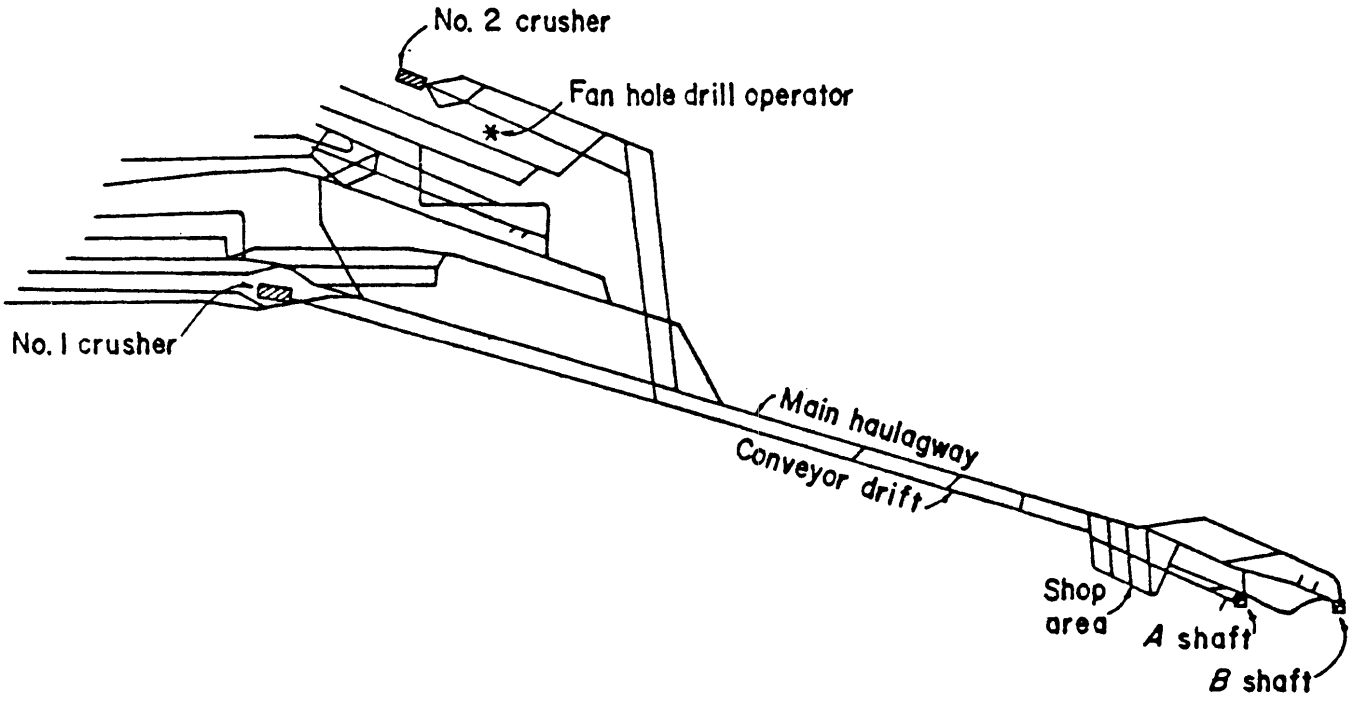

FIGURE A-2. - Underground map of mine, 6th level.

Personnel underground included roving miners in production, haulage, and shop areas, fan-hole drill operators working alone, and maintenance vehicle and ambulance operators. To satisfy the objective to communicate between these personnel and the surface, a guided wireless communication system utilizing equipment available from Motorola, Inc., and Andrew Corp. was selected. Portable HT-220 radios and industrial dispatcher mobile transceivers were chosen for personnel and vehicles, respectively. Andrew Radiax cable, a special type of cable that allows for leakage of signals out of and into itself, was installed throughout the major areas of the mine. Because the total cable length exceeded 2 miles, it was necessary to install two repeaters. Although the system did not require a dispatcher or an operator, a communications center was established at an underground crusher room. Personnel could be selectively paged from the console, and an evacuation alarm could be activated from either the console or an alternate monitor station at the shaft bottom. The monitor station was wired to the surface where a remote control unit provided surface access to the system. During a power failure, the system would operate for 24 hours on backup battery power. A telltale beep in the system signaled that the system had reverted to emergency power. The communication system utilized off-the-shelf, readily available communications equipment and installation hardware. In addition, the system was compatible with the installation and maintenance capabilities of the mine personnel.

Figure A-3 shows the extent of the radiating cable installation. There was 11,000 feet of RX5-1R 7/8-inch Andrew Radiax in the system. The cable attenuation was 1.2 dB/100 ft; thus, two repeaters were required to compensate for signal loss as well as provide adequate power levels for future system expansion.

The cable specifications state that it must be supported every 5 feet. To avoid installing 2,000 anchors in the rock, a 3/16-inch steel messenger wire was attached at 20-foot intervals to roof-bolt-supported T-bars. The cable was then strapped to the messenger wire with standard cable ties.

Some areas were so far away from the installed cable that radio transmissions could not be established. This was overcome by inserting a stub cable with one

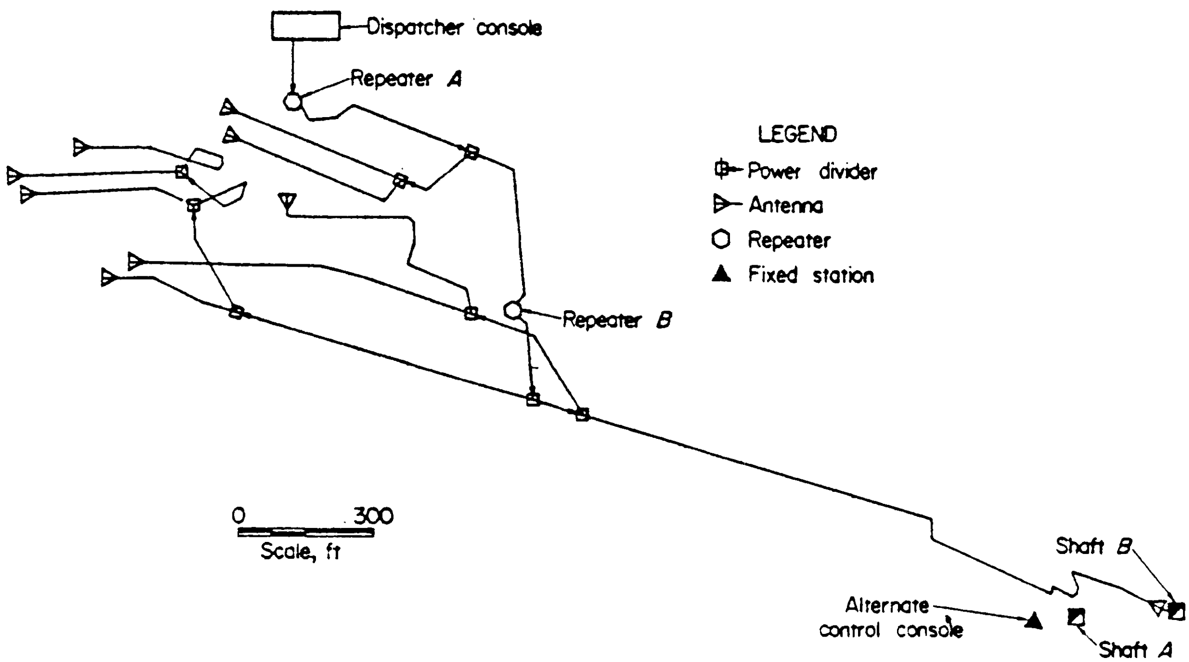

FIGURE A-3. - Leaky feeder cable layout.

end connected through a power divider to the main cable; the other end terminated in an antenna located within several hundred feet of the desired working area.

The repeaters, composed of a unique combination of UHF and VHF units, were bolted together and mounted on pallets for ease of transport within the mine. The UHF and VHF units were interconnected by a squelch and audio interface. Vehicular and personnel communications took place over the leaky coaxial cable on the UHF repeater frequencies, while the control between repeaters, located some 2,000 feet apart, used VHF over the same cable. A 5-MHz UHF transmit and receive frequency separation allowed connection to the common Radiax through a duplexer.

The repeaters were prewired, and the system was assembled on the surface where it underwent several months of burn-in. This procedure eliminated the frustrations of troubleshooting and testing the system underground.

The fan-hole drill operator, equipped with a portable radio attached either to his belt or to a chest pack as he preferred, was also equipped with an accessory noise-reducing earmuff and microphone. The receiver audio was routed to small loudspeakers inside his ear protectors, while the microphone and push-to-talk switch were installed in a similar earmuff which the fan hole drill operator placed over his mouth when he wished to make a radio transmission. All portable radios in the mine were equipped with the provision to use an external speaker microphone accessory so that the radio need not be detached from the operator's belt and raised to his ear or mouth. In noisy locations the use of a noise-reducing speaker-microphone is a necessity.

Two types of vehicular radios were used. The Industrial Dispatcher had all controls, the microphone plug, and speaker located on the transceiver package; this necessitated locating the transceiver within the vehicle operator's reach, which is nearly impossible on some mining vehicles. A better radio for this application was the motorcycle version of the Industrial Dispatcher. All controls and the microphone plug were located on the small, rugged loudspeaker enclosure. The loudspeaker can be mounted in a convenient location, and the larger transceiver unit can be mounted in a more protected location. The antennas are either 1/4-wave whips or Sinclair low-profile blade antennas. The radome version of the blade antenna appears to be the most suitable for mining applications.

A dispatcher control console at the No. 2 crusher could be either manned or unmanned; no operator was necessary for system operation. Paging could be initiated from an encoder at the console to send private messages to pager-equipped radios. Equipping the fan-hole drill operator with a pager-encoded radio prevents the nuisance of his listening to general system traffic. He would only hear messages directed specifically to him. The console also had the provision for sending a warning signal to all radios in the mine. This wailing siren-like signal could be used for mine evacuation in an emergency.

The alternate control station provided an additional access point to the communications network. This station monitored the activity of the fan-hole drill operator. Also, this station was connected by wire line to an intercom unit in the surface guardhouse. The guard could access the system through remote control. This feature was especially desirable during maintenance periods when the underground stations are unmanned or during a mine emergency, to coordinate evacuation and rescue operations.

The mine had outfitted an underground radio shop with the necessary service equipment to maintain the communications system. A full-time Federal Communication Commission second-class licensed radioman was trained in system installation, operation, and maintenance. Reliability of the UHF-VHF system was excellent with negligible downtime. This wireless communications system demonstrated that the objectives of personnel and vehicular underground mine communications can be satisfied. Worker and management acceptance of the system was excellent.

A.9 Mine H

To meet changing communication requirements in many of its mines, one utility company has installed a new multichannel mine dial-page phone system at its underground operations. The first of its type, this fully permissible communication system combines the paging capability of current mine page phones with the advantages of conventional telephones. Manufactured by GAI-Tronics Corp., the Mine Dial-Page Phone System (MDP) has the following features:

1. Each underground station is on a separate circuit ready for instant use depending upon the availability of an open channel in the central switch.

2. When connected to a telephone switchboard through a 12- to 48-volt interface circuitry card provided for each line, any underground station can call another underground station directly, or call any standard telephone at a surface location. Also, any underground station can be called from any aboveground standard telephone.

3. Selective paging capability to any single, specific underground station.

4. A dial-access, all-station paging capability to call personnel not at their normal location, or to alert all underground personnel.

5. Automatic switching to a push-button-operated, all-page-partyline mode in the event of a telephone switchboard power failure or severance of the cable interconnecting the switchboard and the interface cabinet, one of the key components of the MDP system.

6. Plug-in electronic assemblies, wherever possible, to facilitate maintenance and adaptation to changes in mine operations.

The MDP system (fig. A-4) consists of individual phone stations placed at selected sites within the mine, one or more interface cabinets located on the surface, a telephone switchboard, and the necessary multiconductor interconnecting cable. (One pair of conductors is required for each private line.)

Each phone station is contained within a bright yellow, molded polyester-fiberglass-reinforced housing. This material, coupled with the use of stainless steel hardware, gives a corrosion-free enclosure. The station includes a handset, a telephone dial, a loudspeaker, an all-solid-state plug-in amplifier, and a self-contained battery of the standard 12-volt mine page phone type.

In addition, since some power for system operations is supplied from the surface, the mine phones are designed to have individual power to permit emergency communications in the event of a power cutoff. This is accomplished by a standard 12-volt phone battery, while the surface equipment is provided with a 12-volt rechargeable battery, required only in the event that voltage to the dc power supply should be lost.

Located outside each cable entry into the mine is an interface cabinet. The circuitry that converts the telephone switchboard voltages (ac and dc) to permissible levels is contained in this cabinet on a separate plug-in interface card for each telephone line. The cabinet also contains the 12-volt rechargeable battery. This battery automatically powers the system if there is a power failure at the switchboard or in the connecting cable between the switchboard and the cabinet.

The switchboard itself is an important link in the MDP operation.

This mine's initial installation uses a private automatic branch exchange provided and installed by the local

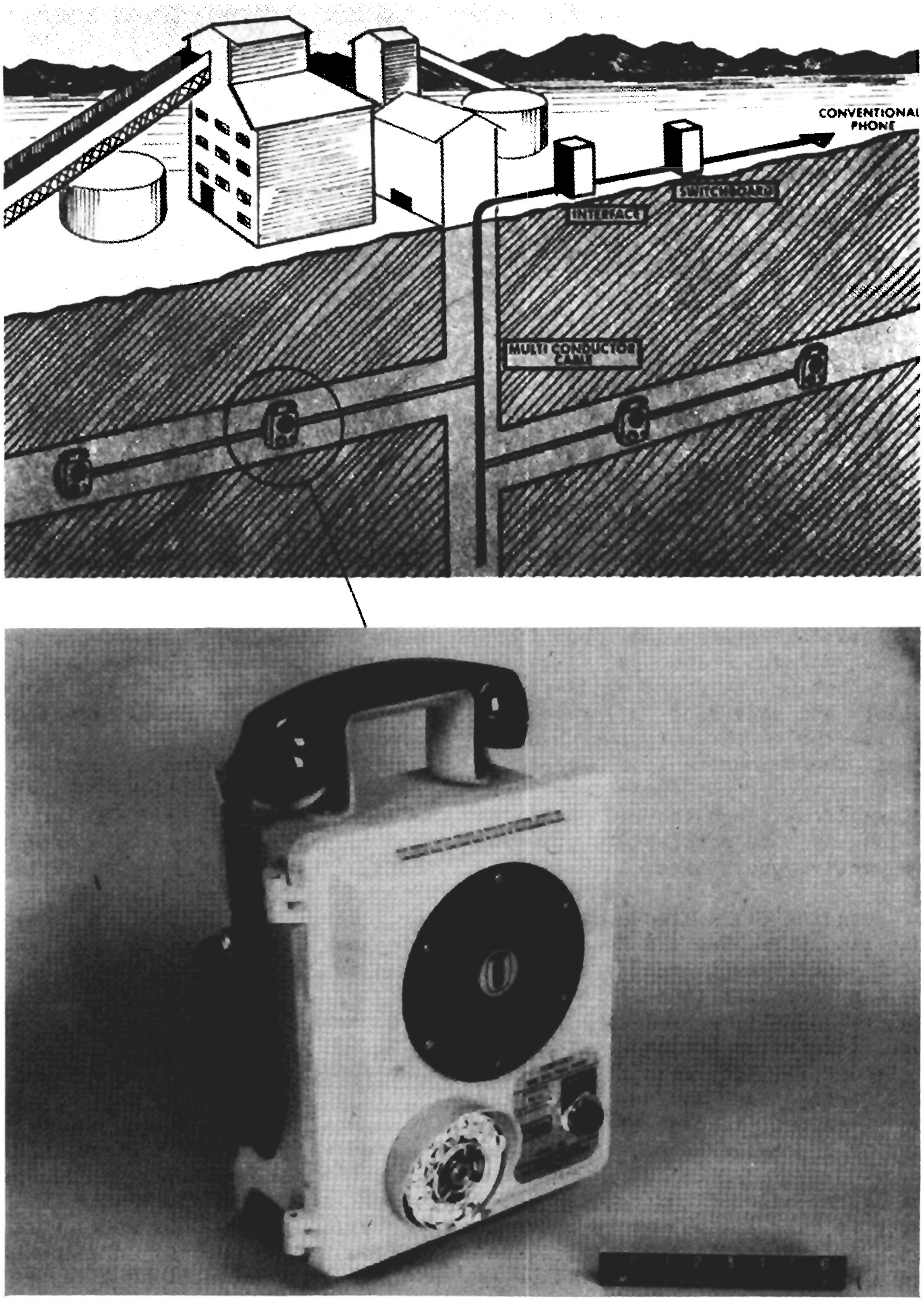

FIGURE A-4. - Typical mine dial-page phone system.

telephone company in the main office building at the mining operation.

An incoming call triggers the interface card circuitry in the cabinet, which begins with the activation of a timed holding circuit that completes the dc loop of the telephone line and halts the incoming ringing signal. The timing circuit holds the line for approximately 40 seconds and initiates additional circuitry which produces a distinctive warble ring tone on the appropriate MDP phone. The ring tone is applied for a 4-second period, and the balance of the 40 seconds is held for the calling party to page a specific person or make an announcement. At the end of this period, if the called station has not answered, the lines are automatically disconnected.

When the station answers before the end of the 40-second hold period, the timing circuitry is returned to its original standby state and the loudspeaker is muted. The party called responds by taking the phone handset from its holder and squeezing a press bar located in the center of the handle. Holding of the telephone line is accomplished by a circuit not associated with the timing circuit, and the connection is held as long as both parties are pressing their respective press bars.

For outgoing calls, the user of the MDP phone simply removes the handset from the holder and presses the press bar. When the familiar dial tone is heard, he can dial his call. Release of the press bar terminates the connection. A delay circuit is provided to maintain the line connection during any brief (2-second maximum) release of the press bar, such as to change hands.

The aforementioned procedures allow one party to call another at a specific location. A separate feature is provided to page a person when his location is unknown. By dialing a special number, a separate amplifier and electronic source within the interface cabinet activate the loudspeaker at each MDP station to provide one-way paging communication. Such a page call will be heard in the handset receiver by all parties engaged in calls to, from, and between MDP phones, but it will not interrupt these conditions; the conversation can continue at the conclusion of the page. The person being paged, however, must dial the person initiating the page to carry on a regular conversation.

The interface cabinet contains a separate fail-safe system to maintain communications in the event of an accidental disconnection of the cable between the cabinet and the telephone switchboard, or if there is a failure of the switchboard's power. A second circuit network, controlled by a switchboard monitor, automatically ties all of the interface cards together in the event of such failure. In this mode, two-way paging and handset conversation can be carried out in a manner similar to that of presentday mine page phones. A push-to-page button is provided for paging in this mode, with each phone having its own battery to provide power for both normal and this alternate-mode operation.

Ability to dial outside calls--including direct-dial long-distance calls--and to receive similar calls is limited only by the telephone switchboard. That is, an MDP phone station can be used to dial any telephone or receive any incoming call that a conventional telephone connected to the same line could handle.

A.10 Mine I

Mine Description

Mine I is a silver mine centrally located in the Couer d'Alene mining district in Idaho. The mine was first opened in 1884 and presently employs over 500 persons, 400 of whom work underground. Main access to the mine is through a 200-foot-long adit to shaft A at the western edge of the mine. A miner proceeds down that shaft to the 3100 and 3700 levels and then eastward through 5,000-foot-long drifts to shaft B, which is collared at the 3,100-foot level.

Miners must then go down that shaft to the active working levels (fig. A-5).

Shaft B is bottomed just below the 6,000-foot level. Ore is being produced on the 4000, 4200, 4400, 4600, 4800, 4000, 5200, and 5400 levels. Level development is in progress on the 5600 level, and shaft station development is in progress on the 5800 level.

The A and B shafts are each provided with electric-powered double-drum hoists and electric-powered single-drum chippy hoists. The double-drum hoists on both shafts are used primarily for hauling ore and waste materials. The chippy hoist on shaft A is used for moving men and materials to all levels as far down as the 4000 level and for hoisting ore from the 4000 level to the 3100 level. The shaft B chippy hoist is on the 3700 level

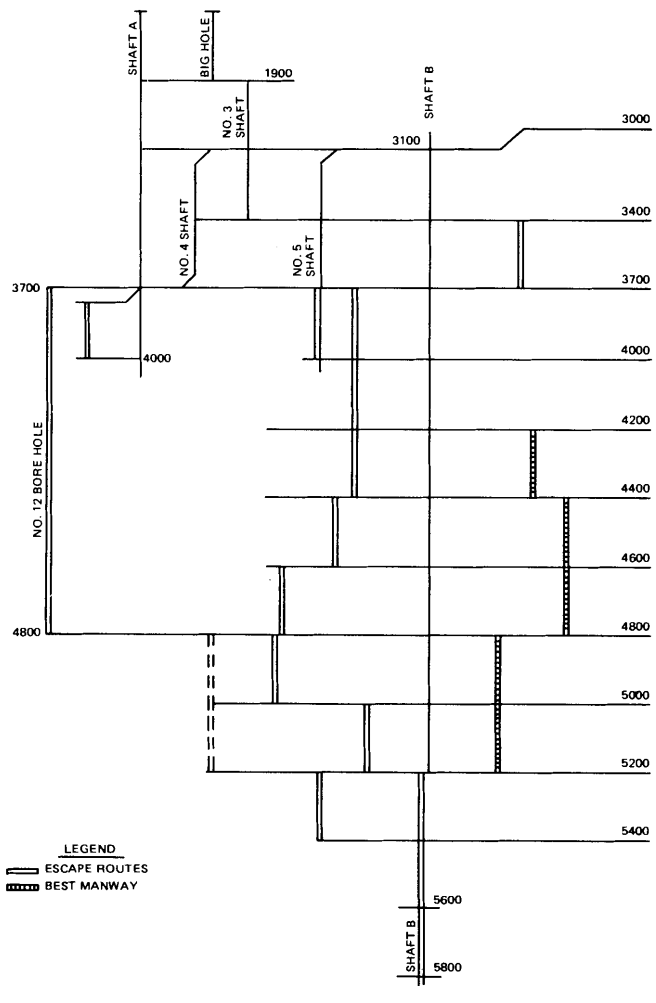

FIGURE A-5. - Mine I, mine map.

and is equipped with a four-deck man cage with a total capacity of 48 men. It is used for servicing all levels below 3700.

Airflow for the mine is dependent upon pressures developed by fans located underground (series ventilation). All of the intake air for ventilation of the mine is coursed down shaft A to the 3100 and 3700 levels. The air is split between these two levels and travels laterally to shaft B. The air is then forced down the shaft B to the lower levels. The return air flows back through ventilation raises and exhaust airways to the surface.

The ore deposits occur as long, generally narrow veins containing sulfides of silver, copper, lead, and antimony in a carbonate quartz gangue. The vein dips range from 45° to 90° and are generally to the south. Strike lengths on the major ore shoots range up to a known maximum of 2,200 feet and are normally exceeded twofold or threefold vertically along the dip of the structure. The true vein width varies considerably but generally averages between 2 and 5 feet.

The steeply dipping fissure veins are mined by the horizontal cut and sandfill method by either breasting down or back stoping. Stopes are developed a maximum of 100 feet along the strike of the vein. Level intervals are 200 feet. A raise climber is used to drive the 6- by 6-foot raises between levels.

All underground transportation is accomplished using either the hoists or battery-powered locomotives on narrow-gage tracks. The mined ore is transported to a muck pocket on the associated haulage level. This ore, or muck as it is called, is then dumped onto the shaft B hoist skips and transported to the 3100 level. The muck is then transported by locomotive to shaft A and hoisted 3,100 feet to the headframe storage bins.

Surface facilities include an office area, warehouse electric shop, machine shop, hoist and compressor house, garage, carpenter shop, mine and mill changehouse for employees, dispensary, and tailing ponds. Engineering personnel are also located at the mine to provide facility planning and better control progress of the mining operations.

Present Mine Communications

The telephone permissibility requirements are not applicable to metal and nonmetal mines such as this mine. A high-dc voltage on the carrier pair, although a potential safety problem, is of much less severity in a metal or nonmetal mine. Therefore, an Anaconda S6A system was installed to provide telephone service underground.

The Anaconda S6A is a seven-channel, frequency division multiplex system. The following items are worth noting in regard to its suitability for mine applications:

1. The system provides a suitable number of channels (seven) on a single wire pair.

2. The mechanical and environmental specifications indicate the ability to operate under the severe conditions found in the mine.

3. The system allows branches to individual conventional dial telephones at any point on the system.

4. Remote units (at the telephones) have batteries that are trickle-charged over the wire pair. This enables the system to be freestanding and not connected to 110-volt power underground.

5. Carrier levels require no adjustment, as the system has automatic gain control circuitry.

The Anaconda S6A system is designed to interface a central office at one end and conventional telephones at the other. It was designed as a transparent substitute for copper pairs connecting the telephone company office to subscriber telephones. To perform its signaling functions, the system receives central office signals at one end (such as the ringing voltage generated by the central office to ring the telephones) and reproduces them at the other end (it remotely generates ringing voltages to ring the bells as needed). Conversely, the system can receive only dial pulses from the telephone end, which it passes to the central office. When used in this way, the system is a transparent substitute for copper pairs; that is, users cannot tell whether the S6A system or copper pairs are being used.

The central switching function of the phone system is handled by a small private branch exchange. System requirements were carefully examined before choosing a location for this PBX. A spare single twisted pair was available from the shaft A surface to deep within the mine. Any additional wiring in the shafts was to be avoided. An air-conditioned room was available in the shaft B area at the 3,700-foot level that met all environmental requirements of the PBX. Additionally, this location was approximately centered with respect to the number of telephones desired in the system. The single twisted pair was opened at this point, thereby forming two independent wire pairs. Carrier terminals were then installed on each pair, and these two independent carrier systems were then connected to the PBX circuits. This provided up to 14 private channels for communication within the mine. One channel in each carrier system was designated for use in a monitor-control system. Of the remaining 12 channels, 5 in each carrier system are used to connect phones to the PBX, and the additional channel is reserved as a spare. Additional phones for critical locations and functions in the 3700 level shaft B area are directly connected to PBX line circuits to provide them with private line service. This minimizes the possibility of getting a busy signal for these phones.

Each phone has battery backup that will allow operation for 24 hours.

APPENDIX B.--FEDERAL REGULATIONS

The following sections of the U.S. Code of Federal Regulations, Title 30, Mineral Resources, Chapter 1--Mine Safety and Health Administration are presented to assist planners of communication systems in insuring that all requirements are being satisfied.

It should be noted that some States have enacted laws that further regulate the use of communications, control, and monitoring equipment in underground mines. Check State and local regulations before proceeding with the installation of new or redesigned equipment.

PART 57—SAFETY AND HEALTH STANDARDS—METAL AND NONMETALLIC UNDERGROUND MINES

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§ 57.1 Purpose and scope.

The regulations in this part are promulgated pursuant to section 6 of the Federal Metal and Nonmetallic Mine Safety Act (30 U.S.C. 725) and prescribe health and safety standards for the purpose of the protection of life, the promotion of health and safety, and the prevention of accidents in underground metal and nonmetallic mines which are subject to that Act. Each standard which is preceded by the word "Mandatory" is a mandatory standard. The violation of a mandatory standard will subject an operator to an order or notice under section 8 of the Act (30 U.S.C. 727). Those regulations in each subpart appearing under the heading "General—Surface and Underground" apply both to the underground and surface operations of underground mines; those appearing under the heading "Surface Only" apply only to the surface operations of underground mines: those appearing under the heading "Underground Only" apply only to the underground operations of underground mines.

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§ 57.11 Travelways and escapeways.

TRAVELWAYS

GENERAL—SURFACE AND UNDERGROUND

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57.11-54 *Mandatory.* Telephone or other voice communication shall be provided between the surface and refuge chambers and such systems shall be independent of the mine power supply.

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§ 57.18 Safety programs.

GENERAL—SURFACE AND UNDERGROUND

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57.18-12 *Mandatory.* Emergency telephone numbers shall be posted at appropriate telephones.

57.18-13 *Mandatory.* A suitable communication system shall be provided at the mine to obtain assistance in the event of an emergency.

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§ 57.19 Man hoisting.

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HOISTING PROCEDURES

57.19-55 *Mandatory.* When a manually operated hoist is used, a qualified hoistman shall remain within hearing of the telephone or signal device at all times while any person is underground.

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SIGNALING

57.19-90 *Mandatory.* There shall be at least two effective approved methods of signaling between each of the shaft stations and the hoist room, one of which shall be a telephone or speaking tube.

57.19-91 *Mandatory.* Hoist operators shall accept hoisting instructions only by the regular signaling system unless it is out of order. In such an event, and during other emergencies, the hoist operator shall accept instructions to direct movement of the conveyances only from authorized persons.

57.19-92 *Mandatory.* A method shall be provided to signal the hoist operator from cages or other conveyances at any point in the shaft.

57.19-93 *Mandatory.* A standard code of hoisting signals shall be adopted and used at each mine. The movement of a shaft conveyance on a "one bell" signal is prohibited.

57.19-94 *Mandatory.* A legible signal code shall be posted prominently in the hoist house within easy view of the hoistmen, and at each place where signals are given or received.

57.19-95 *Mandatory.* Hoisting signal devices shall be positioned within easy reach of persons on the shaft bottom or constantly attended by a person stationed on the lower deck of the sinking platform.

57.19-96 *Mandatory.* Any person responsible for receiving or giving signals for cages, skips, and mantrips when men or materials are being transported shall be familiar with the posted signaling code.

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§ 57.20 Miscellaneous.

GENERAL—SURFACE AND UNDERGROUND

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57.20-32 *Mandatory.* Telephones or other two-way communication equipment with instructions for their use shall be provided for communication from underground operations to the surface.

[34 FR 12517, July 31, 1969, as amended at 35 FR 3677, Feb. 25, 1970; 42 FR 29424, June 8, 1977; 42 FR 57044, Oct. 31, 1977; 44 FR 31919, June 1, 1979; 44 FR 48535, Aug. 17, 1979]

§ 57.21 Gassy mines.

Gassy mines shall be operated in accordance with all mandatory standards in this part. Such mines shall also be operated in accordance with the mandatory standards in this section. The standards in this section apply only to underground operations.

MINE CLASSIFICATION

57.21-1 *Mandatory.* A mine shall be deemed gassy, and thereafter operated as a gassy mine, if:

(a) The State in which the mine is located classifies the mine as gassy; or

(b) Flammable gas emanating from the orebody or the strata surrounding the orebody has been ignited in the mine; or

(c) A concentration of 0.25 percent or more, by air analysis, of flammable gas emanating only from the orebody or the strata surrounding the orebody has been detected not less than 12 inches from the back, face, or ribs in any open workings; or

(d) The mine is connected to a gassy mine.

57.21-2 *Mandatory.* Flammable gases detected only while unwatering mines or flooded sections of mines or during other mine reclamation operations shall not be used to permanently classify a mine gassy. During such periods that any flammable gas is present in the mine, the affected areas of the mine shall be operated in accordance with appropriate standards in this Section 57.21.

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VENTILATION

57.21-20 *Mandatory.* Main fans shall be:

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(f) Provided with an automatic signal device to give warning or alarm should the fan system malfunction. The signal device shall be so located that it can be seen or heard by a responsible person at all times when persons are underground.

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57.21-29 *Mandatory.* Booster fans shall be:

(a) Provided with an automatic signal device to give warning or alarm should the fan system malfunction. The signal device shall be so located that it can be seen or heard by a responsible person at all times when persons are underground.

(b) Equipped with a device that automatically deenergizes the power in affected active workings should the fan system malfunction.

(c) Provided with air locks, the doors of which open automatically should the fan stop.

(d) Equipped with two sets of controls capable of starting, stopping, and reversing the fans. One set of controls shall be located at the fans. A second set of controls shall be at another location remote from the fans.

PART 75—MANDATORY SAFETY STANDARDS—UNDERGROUND COAL MINES

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§ 75.321 Stoppage of fans, plans.

[STATUTORY PROVISIONS]

Each operator shall adopt a plan on or before May 29, 1970, which shall provide that when any mine fan stops, immediate action shall be taken by the operator or his agent (a) to withdraw all persons from the working sections, (b) to cut off the power in the mine in a timely manner, (c) to provide for restoration of power and resumption of work if ventilation is restored within a reasonable period as set forth in the plan after the working places and other active workings where methane is likely to accumulate are reexamined by a certified person to determine if methane in amounts of 1.0 volume per centum or more exists therein, and (d) to provide for withdrawal of all persons from the mine if ventilation cannot be restored within such reasonable time. The plan and revisions thereof approved by the Secretary shall be set out in printed form and a copy shall be furnished to the Secretary or his authorized representative.

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§ 75.508-1 Mine tracks.

When mine track is used as a conductor of a trolley system, the location of such track shall be shown on the map required by § 75.508, with a notation of the number of rails and the size of such track expressed in pounds per yard.

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§ 75.516-2 Communication wires and cables; installation; insulation; support.

(a) All communication wires shall be supported on insulated hangers or insulated J-hooks.

(b) All communication cables shall be insulated as required by § 75.517-1, and shall either be supported on insulated or uninsulated hangers or J-hooks, or securely attached to messenger wires, or buried, or otherwise protected against mechanical damage in a manner approved by the Secretary or his authorized representative.

(c) All communication wires and cables installed in track entries shall, except when a communication cable is buried in accordance with paragraph (b) of this section, be installed on the side of the entry opposite to trolley wires and trolley feeder wires. Additional insulation shall be provided for communication circuits at points where they pass over or under any power conductor.

(d) For purposes of this section, communication cable means two or more insulated conductors covered by an additional abrasion-resistant covering.

[38 FR 4975, Feb. 23, 1973]

§ 75.517 Power wires and cables; insulation and protection.

[STATUTORY PROVISIONS]

Power wires and cables, except trolley wires, trolley feeder wires, and bare signal wires, shall be insulated adequately and fully protected.

§ 75.517-1 Power wires and cables; insulation and protection.

Power wires and cables installed on or after March 30, 1970, shall have insulation with a dielectric strength at least equal to the voltage of the circuit.

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§ 75.521 Lightning arresters; ungrounded and exposed power conductors and telephone wires.

Each ungrounded, exposed power conductor and each ungrounded, exposed telephone wire that leads underground shall be equipped with suitable lightning arresters of approved type within 100 feet of the point where the circuit enters the mine. Lightning arresters shall be connected to a low resistance grounding medium on the surface which shall be separated from neutral grounds by a distance of not less than 25 feet.

[38 FR 4975, Feb. 23, 1973]

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§ 75.701–4 Grounding wires; capacity of wires.

Where grounding wires are used to ground metallic sheaths, armors, conduits, frames, casings, and other metallic enclosures, such grounding wires will be approved if:

(a) The cross-sectional area (size) of the grounding wire is at least one-half the cross-sectional area (size) of the power conductor where the power conductor used is No. 6 A.W.G., or larger.

(b) Where the power conductor used is less than No. 6 A.W.G., the cross-sectional area (size) of the grounding wire is equal to the cross-sectional area (size) of the power conductor.

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§ 75.1003–1 Other requirements for guarding of trolley wires and trolley feeder wires.

Adequate precaution shall be taken to insure that equipment being moved along haulageways will not come in contact with trolley wires or trolley feeder wires.

§ 75.1003–2 Requirements for movement of off-track mining equipment in areas of active workings where energized trolley wires or trolley feeder wires are present; pre-movement requirements; certified and qualified persons.

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(f) A minimum vertical clearance of 12 inches shall be maintained between the farthest projection of the unit of equipment which is being moved and the energized trolley wires or trolley feeder wires at all times during the movement or transportation of such equipment; provided, however, that if the height of the coal seam does not permit 12 inches of vertical clearance to be so maintained, the following additional precautions shall be taken:

(1)(i) Except as provided in paragraph (f)(1)(ii) of this section electric power shall be supplied to the trolley wires or trolley feeder wires only from outby the unit of equipment being moved or transported. (ii) Where direct current electric power is used and such electric power can be supplied only from inby the equipment being moved or transported, power may be supplied from inby such equipment provided a miner with the means to cut off the power, and in direct communication with persons actually engaged in the moving or transporting operation, is stationed outby the equipment being moved.

(2) The settings of automatic circuit interrupting devices used to provide short circuit protection for the trolley circuit shall be reduced to not more than one-half of the maximum current that could flow if the equipment being moved or transported were to come into contact with the trolley wire or trolley feeder wire;

(3) At all times the unit of equipment is being moved or transported, a miner shall be stationed at the first automatic circuit breaker outby the equipment being moved and such miner shall be: (i) In direct communication with persons actually engaged in the moving or transporting operation, and (ii) capable of communicating with the responsible person on the surface required to be on duty in accordance with § 75.1600–1 of this part;

(4) Where trolley phones are utilized to satisfy the requirements of paragraph (f)(3) of this section, telephones or other equivalent two-way communication devices that can readily be connected with the mine communication system shall be carried by the miner stationed at the first automatic circuit breaker outby the equipment being moved and by a miner actually engaged in the moving or transporting operation; and,

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§ 75.1402 Communication between shaft stations and hoist room.

[STATUTORY PROVISIONS]

There shall be at least two effective methods approved by the Secretary of signaling between each of the shaft stations and the hoist room, one of which shall be a telephone or speaking tube.

§ 75.1402–1 Communication between shaft stations and hoist room.

One of the methods used to communicate between shaft stations and the hoist room shall give signals which can be heard by the hoisting engineer at all times while men are underground.

§ 75.1402-2 Tests of signaling systems.

Signaling systems used for communication between shaft stations and the hoist room shall be tested daily.

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Subpart Q—Communications

§ 75.1600 Communications.

[STATUTORY PROVISIONS]

Telephone service or equivalent two-way communication facilities, approved by the Secretary or his authorized representative, shall be provided between the surface and each landing of main shafts and slopes and between the surface and each working section of any coal mine that is more than 100 feet from a portal.

§ 75.1600-1 Communication facilities; main portals; installation requirements.

A telephone or equivalent two-way communication facility shall be located on the surface within 500 feet of all main portals, and shall be installed either in a building or in a box-like structure designed to protect the facilities from damage by inclement weather. At least one of these communication facilities shall be at a location where a responsible person who is always on duty when men are underground can hear the facility and respond immediately in the event of an emergency.

[38 FR 29999, Oct. 31, 1973]

§ 75.1600-2 Communication facilities; working sections; installation and maintenance requirements; audible or visual alarms.

(a) Telephones or equivalent two-way communication facilities provided at each working section shall be located not more than 500 feet outby the last open crosscut and not more than 800 feet from the farthest point of penetration of the working places on such section.

(b) The incoming communication signal shall activate an audible alarm, distinguishable from the surrounding noise level, or a visual alarm that can be seen by a miner regularly employed on the working section.

(c) If a communication system other than telephones is used and its operation depends entirely upon power from the mine electric system, means shall be provided to permit continued communication in the event the mine electric power fails or is cut off; provided, however, that where trolley phones and telephones are both used, an alternate source of power for the trolley phone system is not required.

(d) Trolley phones connected to the trolley wire shall be grounded in accordance with Subpart H of this part.

(e) Telephones or equivalent two-way communication facilities shall be maintained in good operating condition at all times. In the event of any failure in the system that results in loss of communication, repairs shall be started immediately, and the system restored to operating condition as soon as possible.

[38 FR 29999, Oct. 31, 1973]

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§ 75.1713-2 Emergency communications; requirements.

(a) Each operator of an underground coal mine shall establish and maintain a communication system from the mine to the nearest point of medical assistance for use in an emergency.

(b) The emergency communication system required to be maintained under paragraph (a) of this § 75.1713-2 may be established by telephone or radio transmission or by any other means of prompt communication to any facility (for example, the local sheriff, the State highway patrol, or local hospital) which has available the means of communication with the person or persons providing emergency medical assistance or transportation in accordance with the provisions of § 75.1713-1.

APPENDIX C.--EQUIPMENT SUPPLIERS

Pager Phones (And Associated Equipment)

Appalachian Electronics
801 West Monroe Ave.
Ronceverte, WV 24970

ComTrol Corp.
500 Penna. Ave.
Irwin, PA 15642

CSE Mine Service Co.
600 Seco Rd.
Monroeville, PA 15146

Fairmont Supply Co.
Box 501
Washington, PA 15301

FEMCO (See National Mine Service Co.)

Gai-Tronics Corp.
P.O. Box 31-T
Reading, PA 19603

Harrison R. Cooper Systems, Inc.
AME Box 22014
Salt Lake City, UT 84122

JABCO (See Schroeder Brothers Corp.)

Mine Safety Appliances Co.
600 Penn Center Blvd.
Pittsburgh, PA 15235

National Mine Service Co.
4900/600 Grant St.
Pittsburgh, PA 15219

Preiser/Mineco
Jones & Oliver Sts.
St. Albans, WV 25177

Pyott-Bonne, Inc.
P.O. Box 809
Tazewell, VA 24651

Schroeder Brothers Corp.
Nichol Ave.
Box 72
McKees Rocks, PA 15136

Winster Engineering Ltd.
Manners Ave.
Ilkeston, Derbyshire
United Kingdom

Carrier Phones

American Mine Research, Inc.
P.O. Box 1628
Bluefield, WV 24701

ComTrol Corp.
500 Penna. Ave.
Irwin, PA 15642

CSE Mine Service Co.
600 Seco Rd.
Monroeville, PA 15146

Fairmont Supply Co.
Box 501
Washington, PA 15301

FEMCO (See National Mine Service Co.)

Harrison R. Cooper Systems, Inc.
AMF Box 22014
Salt Lake, UT 84122

Mine Safety Appliances Co.
600 Penn Center Blvd.
Pittsburgh, PA 15235

National Mine Service Co.
4900/600 Grant St.
Pittsburgh, PA 15219

Hoist Communications

ComTrol Corp.
500 Penna. Ave.
Irwin, PA 15642

Fairmont Supply Co.
Box 501
Washington, PA 15301

FEMCO (See National Mine Service Co.)

Harrison R. Cooper Systems, Inc.
AMF Box 22014
Salt Lake City, UT 84122

Mine Safety Appliances Co.
600 Penn Center Blvd.
Pittsburgh, PA 15235

National Mine Service Co.
4900/600 Grant St.
Pittsburgh, PA 15219

Republic Wire and Cable
P.O. Box 352
Flushing, NY 11352

Winster Engineering Ltd.
Manners Ave.
Ilkeston, Derbyshire
United Kingdom

PABX and Multiplex Equipment

Anaconda Telecommunications
305 North Muller
Anaheim, CA 92801

Essex Group
800 East Garfield Ave.
Decatur, IL 62525

Executone, Inc.
Dept. TR-77
Long Island City, NY 11101

Phelps Dodge Communication Co.
5 Corporate Park Dr.
White Plains, NY 10604

Pulsecom Div.
Harvey Hubbell, Inc.
5714 Columbia Pike
Falls Church, VA 22041

Reliable Electric Co.
11333 West Addison
Franklin Park, IL 60131

TII Industries, Inc.
100 North Strong Ave.
Lindenhurst, NY 11757

Winster Engineering Ltd.
Manners Ave.
Ilkeston, Derbyshire
United Kingdom

Intercoms

ComTrol Corp.
500 Penna. Ave.
Irwin, PA 15642

Executone, Inc.
Dept. TR-77
Long Island City, NY 11101

FEMCO (See National Mine Service Co.).

Mine Safety Appliances Co.
600 Penn Center Blvd.
Pittsburgh, PA 15235

National Mine Service Co.
4900/600 Grant St.
Pittsburgh, PA 15219

Winster Engineering Ltd.
Manners Ave.
Ilkeston, Derbyshire
United Kingdom

Radio Pocket Pagers

Executone, Inc.
Dept. TR-77
Long Island City, NY 11101

FEMCO (See National Mine Service Co.)

General Electric Co., Mobile Radio Dept.
P.O. Box 4197
Lynchburg, VA 24502

National Mine Service Co.
4900/600 Grant St.
Pittsburgh, PA 15219

Leaky Feeder Equipment

Andrew Corp.
10500 West 153d St.
Orland Park, IL 60462

Winster Engineering Ltd.
Manners Ave.
Ilkeston, Derbyshire
United Kingdom

Mobile Radio Equipment

Fairmont Supply Co.
Box 501
Washington, PA 15301

General Electric Co., Mobile
Radio Dept.
P.O. Box 4197
Lynchburg, VA 24502

Motorola Communications & Electronics
1301 East Algonquin Rd.
Schaumburg, IL 60196

Lee Engineering
2025 West Wisconsin Ave.
Milwaukee, WI 53201

Phelps Dodge Communication Co.
5 Corporate Park Dr.
White Plains, NY 10604

Winster Engineering Ltd.
Manners Ave.
Ilkeston, Derbyshire
United Kingdom

Closed Circuit Television

Midwest Telecommunications Div.,
Midwest Corp.
300 T First Ave.
Nitro, WV 25143

Winster Engineering Ltd.
Manners Ave.
Ilkeston, Derbyshire
United Kingdom

Remote Control and Monitor Equipment

American Mine Research, Inc.
P.O. Box 1628
Bluefield, WV 24701

BIF Accutel Inc.
1339 Lawrence Dr.
Newbury Park, CA 91320

ComTrol Corp.
500 Penna. Ave.
Irwin, PA 15642

FEMCO (See National Mine Service Co.)

General Electric Co., Mobile Radio Dept.
P.O. Box 4197
Lynchburg, VA 24502

General Equipment & Manufacturing
Co., Inc.
3300 Fern Valley Rd.
P.O. Box 13226
Louisville, KY 40213

Mag-Con, Inc.
1626 Terrace Dr.
St. Paul, MN 55113

Mine Safety Appliances Co.
600 Penn Center Blvd.
Pittsburgh, PA 15235

National Mine Service Co.
4900/600 Grant St.
Pittsburgh, PA 15219

Notifier of Western Penn. Inc.
3460 Babcock Blvd.
Pittsburgh, PA 15237

Pace Transducer Co., Div. of
C. J. Enterprises
P.O. Box 834
Tarzana, CA 91356

Pulsecom Div.
Harvey Hubbell, Inc.
5714 Columbia Pike
Falls Church, VA 22041

Pyott-Bonne, Inc.
P.O. Box 809
Taxewell, VA 24651

RFL Industries, Inc.
Boonton, NJ 07005

Stevens International Inc.
P.O. Box 619
Kennett Square, PA 19348

Winster Engineering Ltd.
Manners Ave.
Ilkeston, Derbyshire
United Kingdom

Environmental Sensors

Methane:

Mine Safety Appliances Co.
201 North Braddock Ave.
Pittsburgh, PA 15208

National Mine Service Co.
300 Koppers Bldg.
Pittsburgh, PA 15216

Bacharach Instrument Co.
625 Alpha Dr.
Pittsburgh, PA 15238

CSE Mine Service Co.
2000 Eldo Rd.
Monroeville, PA 15146

Preiser/Mineco
Jones and Oliver Sts.
St. Albans, WV 25177

Appalachian Electronics Instruments
810 West Monroe Ave.
Ronceverte, VA 24970

American Mine Research, Inc.
P.O. Box 1628
Bluefield, WV 24701

Carbon monoxide:

Mine Safety Appliances
201 North Braddock Ave.
Pittsburgh, PA 15208

Energetics Sciences
85 Executive Blvd.
Elmsford, NY 10523

Oxygen:

Beckman Instruments Inc.
3900 River Rd.
Schiller Park, IL 60176

Edmont-Wilson
1300 Walnut St.
Coshocton, OH 43812

Mine Safety Appliances Co.
201 North Braddock Ave.
Pittsburgh, PA 15208

Survivair Div. of U.S. Divers
3323 West Warner Ave.
Santa Ana, CA 91776

Teledyne Analytical Instruments
333 West Mission
San Gabriel, CA 91776

Oxides of nitrogen:

Energetics Sciences
85 Executive Blvd.
Elmsford, NY 10523

Air flow sensors:

Alnor Instrument Co.
7301 North Caldwell Ave.
Niles, IL 60648

J-Tec Associates, Inc.
317 Seventh Ave. SE
Cedar Rapids, IA 52401

Taylor Instrument
Consumer Products Div.
Arden, NC 28704

Atmospheric pressure:

Pace Transducer Co., Div. of
C. J. Enterprises
P.O. Box 834
Tarzana, CA 91356

Leeds and Northrup Co.
Dept. MD337
North Wales, PA 19454

Seismic Equipment

Pace Transducer Co., Div. of
C. J. Enterprises
P. O. Box 834
Tarzana, CA 91356

Consultants

Arthur D. Little, Inc.
25 Acorn Park
Cambridge, MA 02140

Advance Mining Services
616 Beatty RD. Industrial Court
Monroeville, PA 15146

ComTrol Corp.
500 Penna. Ave.
Irwin, PA 15642

CSE Mine Service Co.
600 Seco Rd.
Monroeville, PA 15146

Fairmont Supply Co.
Box 501
Washington, PA 15301

General Electric Co., Mobile Radio Dept.
P.O. Box 4197
Lynchburg, VA 24502

Midwest Telecommunications Div.,
Midwest Corp.
300 T First Ave.
Nitro, WV 25143

Mineral Services Inc.
1276 West Third St.
Cleveland, OH 44113

National Coal Board
Mining Research and Development
Establishment
Stanhope Bretby
Burton Upon Trent DEISOQD
United Kingdom

National Mine Service Co.
4900/600 Grant St.
Pittsburgh, PA 15219

Pyott-Bonne, Inc.
P.O. Box 809
Tazewell, VA 24651

Corma Resources
2857 Mount Vernon SE
Cedar Rapids, IA 52403

U.S. Bureau of Mines
4800 Forbes Avenue
Pittsburgh, PA 15213

Winster Engineering Ltd.
Manners Avenue
Ilkeston, Derbyshire
United Kingdom

Fire Detection Devices

ADT Co., Inc.
155 Sixth Ave.
New York, NY 10013

The Ansul Co.
One Stanton St.
Marinette, WI 54143

B. & B. Electric Manufacturing Co.
Seward, PA 15954

Gammaflex Corp.
821 Michael Faraday Dr.
Reston, VA 22070

JABCO
Schroeder Brothers Corp.
P.O. Box 72
Nichol Ave.
McKees Rocks, PA 15136

McJunkin Corp.
P.O. Boc 2473
1400 Hansford St.
Charleston, WV 25311

Mine Safety Appliances Co.
201 North Braddock Ave.
Pittsburgh, PA 15203

National Mine Service Co.
3000 Koppers Bldg.
436 Seventh Ave.
Pittsburgh, PA 15219

Notifier of Western Pennsylvania
3283 Babcock Blvd.
Pittsburgh, PA 15237

Prieser
Jones and Oliver Sts.
St. Albans, WV 25177

Pyott-Boone, Inc.
P.O. Box 809
Tazewell, VA 24651

Southern Engineering and Equipment Co.
P.O. Drawer 329
95 Third St., NE
Graysville, AL 35073

Figure-8 Communication Cable

Delphi Wire & Cable
700 Carpenters Crossing
Folcroft, PA 19032

General Cabie Corp.
600 Reed Rd.
Broomall, PA 19008

Industrial Component Inc.
342 Madison Ave.
Suite 702
New York, NY 10017

Okonite Co.
100 Hilltop Rd.
Ramsey, NJ 07446

APPENDIX D.—GLOSSARY OF TERMS

Analog — A method of generating or transmitting information that is represented by a continuous (as opposed to digital) voltage or current that is proportional to the information.

Angstrom — A unit of length. Usually used to measure the wavelength of light or other radiation. One angstrom is equal to one hundred-millionth of a centimeter.

AM — Abbreviation for "amplitude modulation." Modulation in which the amplitude of the information waveform modulates the amplitude of a carrier wave.

Attenuation — The decrease in signal strength during its transmission from one point to another. Attenuation is usually expressed in decibels.

Balance point — In an electronic bridge circuit, the point at which the electrical resistances in both branches of the network are the same.

Bandwidth — The difference (in cycles per second) between the highest and lowest frequency components required for the adequate transmission of information.

Baseband — The original frequency band (before modulation) of a signal. Usually refers to the baseband of an audio or voice signal, which is approximately 300 to 5,000 Hz.

Binary — A digital numbering system with the base 2. In a binary system there are only two possibilities for each digit, selection, choice, or condition. For example, a simple switch is a binary device since it is either open or closed.

Bridge — An electrical bridge circuit is a network arranged so that voltage or current in one branch of the circuit may be measured by adjusting components in another branch of the circuit.

CATV — Abbreviation for "community antenna television," commonly known as cable television.

Characteristic impedance — Pertaining to transmission lines. For a uniform and infinitely long line, it is the ratio of applied voltage to current induced at a given frequency. It is measured in ohms and usually designated as Zo. For maximum signal transfer, the Zo of a line should equal the Zo of a source and load.

CO — Abbreviation for "central office." Refers to the telephone company's central office.

Cross talk — Cross-coupling or interference between speech channels or wire pairs.

dB — Abbreviation of "decibel," a unit that represents the ratio between two amounts of power on a logarithmic scale. A value of +3 dB indicates a doubling of power, while -3 dB is a halving of power.

dBm	The normal signal level in a pager phone is about 1 milliwatt (1 mW). The designation 0 dBm is used to indicate this 1-mW reference level. Thus, +3 dBm is 3 dB above the reference (2 mW) and -3 dBm is 3 dB below the reference (0.5 mW).
Demodulation	A device that receives a carrier wave and recovers or "reconstructs" the original voice or information signal from the carrier wave.
DTMF	Abbreviation for "dual-tone multifrequency." A phone signaling method in which each digit dialed is converted to a dual-tone signal that will be recognized by the telephone office or PABX switching equipment. These control tones can be heard in the earpiece when dialing on many pushbutton phones.
Electromagnetic	Having both electric and magnetic properties.
Encoder	A unit that produces coded output combinations depending upon the specific input selected.
FDM	Abbreviation for "frequency-division multiplexing." A process in which two or more signals are sent over a common path by sending each one in a different frequency band.
Feedback	In a transmission system, or electrical device, the returning of a fraction of the output signal to the input.
FM	Abbreviation for "frequency modulation." Modulation in which the amplitude of the information waveform modulates the frequency of a carrier signal.
FSK	Abbreviation for "frequency-shift keying." A form of FM in which a binary code is transmitted by switching a carrier signal between two different frequencies.
Geophone	A device used to detect seismic vibrations or shockwaves in the earth.
Hall effect	In a conductor located in a magnetic field that is perpendicular to the direction of current, the production of a voltage perpendicular to both the current and the magnetic field.
Handset	A receiver-transmitter held by hand.
Headset	A receiver-transmitter that can be attached to the person to allow "hands-free" operation.
Hybrid	A circuit or communications system that is made up of two or more dissimilar systems.
Hz	Abbreviation for Hertz. A unit of frequency equal to 1 cycle per second.
Impedance	The total opposition (reactance plus resistance) that a circuit or transmission line offers to the flow of electrical current.

Inductively coupled	Method of inducing a signal into one conductor or wire from another conductor even though there may be no mechanical connection between the two conductors. (The magnetic field set up in the space around a conductor carrying alternating current will induce a signal in other nearby conductors.)
Joule heating	In an electrical circuit, the heat produced by the flow of current in the circuit.
Leaky feeder	A specially designed coaxial cable that allows radio signals to leak into or out of the cable so that they may be picked up by radio transceivers.
LED	Abbreviation for "light-emitting diode." A solid state electronic device that emits light when a current flows through it.
Magnetic field	The region surrounding a magnet or a conductor through which current is flowing.
Magneto	An ac generator for producing ringing signals.
Milliammeter	An electric current meter calibrated in milliamperes.
Modem	A device that is both a modulator and a demodulator. A modem is a two-way device that both modulates (transmits) and receives (demodulates) a signal.
Modulator	A device that modulates a voice or information signal and transmits the resulting carrier wave.
Monochromatic	A signal or beam of light consisting of a single wavelength or of a very small range of wavelengths.
Multiplexed	The simultaneous transmission of two or more signals using a single transmission path or wire.
PABX	Abbreviation for "private automatic branch exchange." A private branch exchange in which automatically controlled switches make connections between the phones in the system.
PAM	Abbreviation for "pulse amplitude modulation." Modulation in which the value or amplitude of each sample of the information waveform modulates the amplitude of a pulse carrier.
Parasitic coupling	The coupling of radio waves or electrical signals from one wire or medium to another with the result that the signal strength in the first conductor is decreased.
PBX	Abbreviation for "private branch exchange." A private manual telephone exchange requiring an operator at a switchboard to make connections between the phones.
PCM	Abbreviation for "pulse coded modulation." Modulation in which the value or amplitude of each sample of the information waveform is quantitized and transmitted as a digital binary code.

PDM	Abbreviation for "pulse duration modulation." Modulation in which the value or amplitude of each sample of the information waveform modulates the duration, or "width," of a pulse.
Piezoelectric	The property of certain crystals or materials that produce a voltage when subjected to mechanical stress.
Potentiometer	An electromechanical device with a sliding contact on a resistor. Movement of the sliding contact changes the electrical resistance of the circuit and allows the electronics to sense the position of the sliding contact.
PPM	Abbreviation for "pulse position modulation." Modulation in which the value or amplitude of each sample of the information waveform modulates the position in time of a pulse.
Propagation	The travel of electromagnetic (radio) or sound waves through a medium.
PSK	Abbreviation for "phase shift keying." A form of FM in which a binary code is transmitted by shifting the phase of a carrier signal.
Q	The "Q" of an ac circuit is the ratio of its reactance to its resistance. The voltage developed across the reactance is usable signal, but the voltage developed across the resistance subtracts from the signal. Thus, a high Q indicates an efficient, low-loss ac circuit.
Reactance	The opposition to the flow of alternating current (ac). Capacitive reactance (X_C) is the opposition offered by capacitors, and inductive reactance (X_L) is the opposition offered by a coil or other inductance.
rf	Abbreviation for radiofrequency. Any frequency at which electromagnetic radiation of energy (radio waves) is possible.
RFI	Radio frequency interference.
Reluctance	The resistance of a magnetic path to the flow of magnetic line of force. Aluminum has a high reluctance; iron has a low reluctance.
Repeater	A device that detects or receives a signal and rebroadcasts the same signal.
Resistance	The opposition to the flow of direct current (dc). The unit of resistance is the ohm.
Resonate	To bring to resonance; to tone.
Simplex	A communication system, or other device, that operates in only one direction (either transmit or receive) at a time.

Sine wave	The wave form corresponding to a pure, single-frequency oscillation.
SWR	Abbreviation for "standing wave ratio." On a transmission line or antenna element the current and voltage set up by waves traveling in the opposite direction are characterized by the presence of a number of stationary maximum and minimum points in the distribution curve. SWR is the ratio of the maximum to minimum current or voltage of these stationary waves.
Synchronize	To maintain one operation (or signal) in step with another.
TDM	Abbreviation for "time-division multiplexing." A process by which two or more channels of information are transmitted over the same link by allocating a different time interval for the transmission of each channel.
Transducer	A device that converts energy from one form to another. A seismic transducer, for instance, converts seismic shock waves into electrical signals.
Transceiver	A device that is both a transmitter and a receiver. A two-way CB radio is a transceiver.
Tuned voltmeter	A voltmeter that has been tuned to detect voltage levels or signal strengths at specific frequencies.
UHF	Ultra high frequency, 300 to 3,000 MHz
Ultrasonic	Having a frequency above that of audible sound.
vf	Abbreviation for voice frequency (same as audio frequency). The frequencies corresponding to speech or other audible sound wave.
VHF	Very high frequency, 30 to 300 MHz.
Vortex	A whirlpool or eddy caused by a fluid or gas moving past an obstruction.
Waveguide	A hollow, round or rectangular pipe (or tunnel), used as a transmission line for signaling.

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